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ABSTRACT

COMETS Science (Career Oriented Modules to Explore Topics in Science) was developed to demonstrate to early adolescents that learning mathematics and science concepts can have payoff in a wide variety of careers and to encourage early adolescent students (grades 5-9), especially girls, to consider science-related careers. The program provides 24 modules (sets of supplemental lesson plans) to enable teachers to bring into their science or mathematics classes community resource people to (1) teach a captivating science lesson; (2) tell students how the science concept being demonstrated is used in their career; and (3) talk with students and answer questions about their career. In general, each module describes three activities plus extension activities which can be used to follow up a resource person's visit. Modules are presented in three sections, focusing on: physical science/engineering; life science/health; and mathematics, calculating, and computers. A separate set of 24 biographical sketches (COMETS Profiles) is also available for use with the program. (Author/JN)

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COMETS Science

Career Oriented Modules To Explore Topics In Science

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COMETS Profiles, a companion curriculum package, provides 24 sketches of women in various science careers plus comprehension, vocabulary, and writing exercises for use in language arts. COMETS Profiles may supplement this volume or be used on its own. For further information about COMETS Profiles, contact COMETS, 205 Bailey Hall, Lawrence, Kansas 66045 or call 913/864-4435.

The Trial Edition of COMETS Profiles may be purchased for $19.95. A sample profile costs $1.50; and additional modules (up to 4) cost 95¢ each. Send check or official purchase order made payable to the University of Kansas. Kansas residents add 3.5% sales tax. No requests to be billed can be accepted.

Trial Edition **Second Printing**

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Logic	Computer Programmer
	Systems Analyst

BIBLIOGRAPHY OF BIOGRAPHIES

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Acknowledgements

Hundreds of people - teachers, students, scientists, science educators, and others concerned about the project goals - have provided their invaluable assistance throughout the COMETS project. In addition to the authors and illustrator listed on the cover, I would particularly like to recognize the other COMETS staff members: JoBeth Allen (Profiles author), Philip Brody (curriculum development), Carolyn Derusseau (evaluation and Profiles), Karen Erb (evaluation), Thomas Erb (evaluation and project co-director), and Ruth Noyce (Profiles author and editor). Many other University of Kansas staff members, notably the School of Education's Instructional Technology Center and Word Processing Center, and the secretarial staff of the Department of Curriculum and Instruction, supported COMETS immeasurably.

From our Advisory Board, Jane Lucas gave life to the seed of an idea which grew into the Profiles, Jeannot Seymour illustrated the Profiles, and Peg Young provided access for us to a large portion of our evaluation sites; but we also acknowledge the contributions of each and every Advisory Board member: Ramona Anshutz, Barbara Ballard, Barbara Bloom, Pris Callison, Jan Chapman, Nancy Dahl, Marjorie Franklin, Ruth Gennrich, Shirley Harkness, Rosemary Henderson, Rene Holland, Deb Holmes, Tyra Manning, Diane McDermott, Marily Rhudy, Judy Roitman, John Sherbo, Caryl Smith, Jan Woerner, Connie Welsh, and Jody Woods.

Various aspects of evaluation took place in over 80 classrooms and involved about 2000 students and dozens of resource people. The materials were also reviewed by nearly 70 scientists and science educators from around the country. We greatly appreciate the assistance, critical comments, and suggestions from each of these sources.

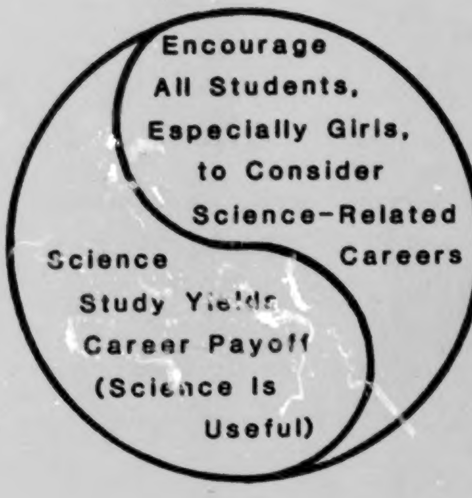
Finally, we extend our thanks to Linda Kahan and Mary Ann Ryan who faithfully served as our project managers at the National Science Foundation. We appreciate very much the positive and professional relationship we had through them with NSF.

Walter S. Smith

Teacher's Guide

Goals:

COMETS has two primary goals: first, demonstrate to early adolescents that continued study of science and math can have a career payoff, whether one is considering a "hard science" career such as researcher or engineer or a career for which the need for science and math skills is less apparent. Examples of the latter careers include dietician, teacher and farmer. COMETS aims to answer the perennial and justifiable question, "Why do I gotta learn that?"


Encourage All Students, Especially Girls, to Consider Science-Related Careers
Science Study Yields Career Payoff (Science Is Useful)

COMETS' second goal is to pique students' interest in science and thereby to encourage all early adolescents, especially girls, to consider entering a science-related[1] career and to continue studying the science and math courses which will enable, but not force, the eventual entry into these careers. As students make course selections in junior and senior high, they frequently inadvertently close, or at least make difficult, the choice of many careers. By high school graduation large numbers of students have shut many career doors for themselves by opting out of science and math. Dropping out of math and science affects both boys and girls; but although the situation has been changing to some degree, girls are more prone to question the career payoff of science and math courses and to steer away from these courses. COMETS aims to encourage students to keep the doors open by staying in math and science.

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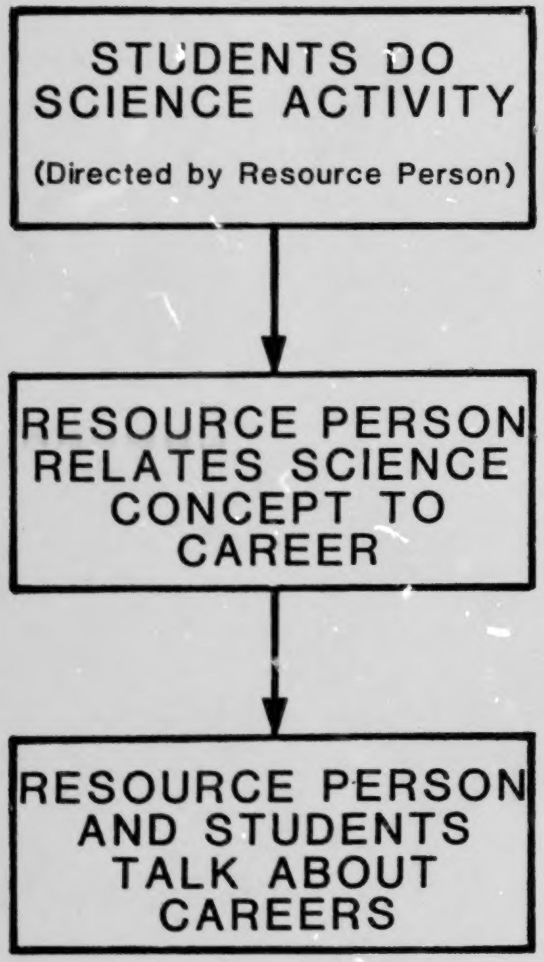
[1] COMETS' definition of science-related career is quite inclusive. Science-related careers include not only "scientist" careers (e.g., physicist, wildlife biologist, or geologist) and "science application careers" (e.g., veterinarian, nurse, or engineer) but also careers which require science skills but which are not usually thought of as needing science (e.g., home economics extension agent, landscape architect, or detective) plus careers emphasizing mathematical skills (e.g., mathematician, actuary, or computer systems analyst) and social science careers (e.g., psychological social worker, economist, or sociologist).

How COMETS Works:

COMETS Science provides 24 sets of supplemental lesson plans for grades five to nine to enable teachers to bring into their science or math class community resource people to (1) teach a captivating science lesson, (2) tell students how the science concept being demonstrated is used in their[2] career, and (3) talk with students and answer questions about their career. For example, in connection with a life science unit, a teacher might contact


STUDENTS DO SCIENCE ACTIVITY
(Directed by Resource Person)
RESOURCE PERSON RELATES SCIENCE CONCEPT TO CAREER
RESOURCE PERSON AND STUDENTS TALK ABOUT CAREERS

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[2] We use "they, their, them" for third person singular in place of "he/she, her/his, and her/him." This is consistent with everyday usage (e.g., we say, "Give 'em their book.") Some grammarians have accepted this everyday usage as standard, and there is precedent for changing pronouns (e.g., "you and your" has replaced "thy and thine" as second person singular).

a physician to come to class. The physician, using directions found in the COMETS module, Fit N' Trim, and provided by the teacher, could begin their visit by asking students to look for personal traits such as tongue rolling, hitchhiker's thumb, or earlobe attachment. After briefly explaining that each of these traits is inherited, the physician could turn to telling students about doctors' need to understand heredity as they do their jobs. For example, they might tell students why a family history is included in a physical exam or they might describe the characteristics and care provided for conditions such as cystic fibrosis, sickle cell anemia, or Down's Syndrome. Finally, the physician could tell students more about their job, how they selected that field and trained for it, and how their career fits in with other parts of their lives (e.g., family, leisure activities, or community work).[3]

Why Women and Men As Resource People?

COMETS especially encourages the inclusion of women, along with men, among the community resource people used by a teacher in any one course. Women can become role models for early adolescent girls who may question whether science careers can be compatible with being a spouse and parent and whether the pursuit of science leads to a loss of femininity. Moreover, a female resource person can demonstrate that women can be interested and enriched by the study and application of science and that they can be successful in such pursuits.

Boys, too, will profit from the visit of both women and men as resource persons. After all, many of these boys will have female relatives and/or friends who will be interested in a science career. By having seen and talked with women in such careers, these boys will be better able to understand and perhaps support or even encourage their female relatives or friends in pursuing science careers. Further, as more women enter science careers, boys will need to become accustomed to the idea of using the services of women as professionals in science -- for example, as a patient of a woman physician. In any event, whether the resource person is female or male, the students -- both girls and boys -- will observe how science can have a career payoff and will learn more about the science concepts and careers they are studying.

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[3] Career includes not only what one does on the job but also other important aspects of one's life, including roles of spouse and parent, if applicable, and one's leisure activities, community work, and so forth. Too frequently students (and adults) dissociate job from the rest of one's life. Ideally, the resource person will talk with students about career in a quite broad sense, so that students will acquire this inclusive idea.

In general, a COMETS module describes three activities plus extension activities which can be used to follow up a resource person's visit. Each module contains at least one brief activity for the use of resource people who can spend only a little time in the classroom. (Brief activities are indicated by the lightning symbol. ⚡) In most cases, a teacher will choose a COMETS module which relates to and supplements a topic already part of the science course. (See the Table of Contents for a list of modules and their major topics.) Next, the teacher will contact a resource person who uses those science concepts in their career. (Each module lists possible resource people and ways of contacting them.)

Having made this contact, the teacher and resource person will jointly apply one or more of these criteria to choose an activity from the several available in the module: (1) Does the activity present a science concept which the resource person also uses on the job? (2) Does the activity fit in with what is being taught and the students' ability? (3) Is there sufficient time to do the activity? (In addition to brief activities, directions are frequently given for how a resource person could be used in connection with a longer activity.) (4) Are materials available? (An effort has been made to use simple, readily available materials. Most modules include at least one activity for which no special equipment is needed or for which only a worksheet needs to be reproduced.)

As already mentioned, the lightning symbol is used to call attention to shorter activities. Other symbols, however, call attention to other special features of activities.

👁 - These activities require students to observe some materials and/or processes. In some cases written data is called for.

1234 - When students are asked to make quantitative observations, this ruler symbol is used. The English system of measurement, rather than the metric, is used throughout. However, if your class uses metric measurement, you can change the units to metric. English units are used because in our judgment, teachers and resource people who work with metrics can generally easily make the conversion of English units to metric. However, teachers and resource people who use English units may find conversion difficult.

- In some activities students manipulate materials to ascertain the effect of one variable on another. When some experimentation is involved in the activity, the test tube symbol appears.

+/- - We have consciously attempted throughout to include some activities in which mathematical skills are used and can be practiced by students. This symbol denotes activities in which some computation is required.

Prior to a resource person's visit, the teacher should introduce the science concept to the extent agreed upon by the teacher and resource person. Also, the person's career should be introduced and the students should prepare career questions for the resource person. (See the box on page six for suggestions.) As students prepare questions, the teacher can suggest additional questions to help them think about career topics which do not typically occur to early adolescents.

Potential Career Questions for the Resource Person

Job Characteristics

What's your job like? What do you do?

What's a typical day, week, or month like?

What's the best part of your job? The worst?

Do you get to choose how you spend your work day?

What benefits besides salary come from your career?

What do you expect to be doing in your career in the future? Where's it heading?

Career Selection

Why did you decide to become a __________?

When you were my age, what did you want to do for a career and how did your plans change?

Should I take more math and science? How much? What kinds? Any other courses?

What other careers would interest a person with your abilities and interests? Are there any areas like your current field that will be growing in the future?

How can I find out whether I'd like a career in your area?

Relationship to Other Roles

How do you arrange your life in order to have a career, a family, leisure time activities, or community responsibilities? Please talk in terms of daily, weekly, monthly, or annual activities.

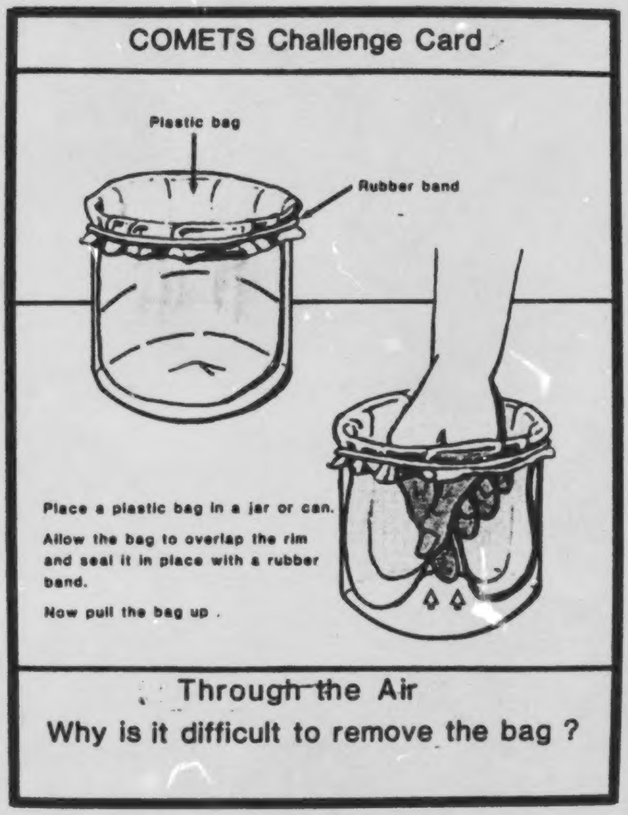
Relating to Others

How do other people relate to you on the job? (This question should especially be asked of people in nontraditional careers.)

Have you found it necessary to do anything special in your career, since you may be in a minority?

Following a resource person's visit, the teacher should tie up any loose ends by answering students' questions about the science concept and the career. Plans for visits by additional resource people can be made as students' interest is opened in new directions.

In addition to the resource person's visit, which is the heart of COMETS, other aides are provided. All modules contain COMETS Challenge Cards and/or student worksheets. The Challenge Cards, like this example, suggest open-ended student investigations. The directions can be given orally; or the Challenge Cards can be reproduced and distributed. To make the Challenge Cards reusable, they can be reproduced, mounted, laminated, and cut apart.



COMETS Challenge Card

Place a plastic bag in a jar or can.

Allow the bag to overlap the rim and seal it in place with a rubber band.

Now pull the bag up .

Through the Air

Why is it difficult to remove the bag ?

Each module describes science contributions made by women in the field covered by the module. Too often students think Madame Curie was the only woman who ever did anything in science; and this lack of information leads to the erroneous conclusion that science and women don't mix. This notion can be dispelled by telling students about the contributions, some of which were recognized with a Nobel Prize, described in the module.

At the end of each module is some basic information about the career(s) featured in the module; and the teacher may want to pass along this information. However, the intent of COMETS is that most career information will be provided directly to students by the resource person. Also, interested students can be referred to the excellent U.S. Department of Labor Bulletin 2001, Exploring Careers, 1979, (order stock number s/r 029-001-02224-7 from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402; the cost is $10 for the 550 page book or $2 for each of 15 individual chapters.) Finally, a bibliography lists sources of directions for related science activities and additional career information.

Frequency of Use:

Use COMETS as often as you like. Some teachers will use only one or two modules in a school year; others will use modules throughout the year. One school district is working on assigning the modules to grade levels, five through nine, according to how the modules fit the district's science curriculum. Thus, each module will be used sometime during the five grades, but only four or five modules will be used each year. Such systematic adoption of COMETS is probably the exception; in most cases the modules' use will be decided individually by teachers according to their teaching plans and availability of resource people.

Profiles:

COMETS separately provides 24 Profiles, each of which describes the career of a woman in a science-related career. (Since some teachers may have difficulty finding women resource people, since articles comparable to Profiles about men are more available than about women, and since, as pointed out previously, women role models can have a positive effect for students, only Profiles about women have been included.) To supplement a resource person's visit, a relevant Profile could be provided students. For instance, after a visit from an engineer, students could read about other engineers and/or about other physical science career people such as a geologist, physicist, or chemist.

The Profiles could be used in science class or as the basis for a coordinated language arts lesson. To facilitate their use in language arts (as lessons by themselves or coordinated with science), each Profile contains a content quiz, word building activities, and ideas for writing and projects.

(For more information about Profiles, write COMETS, 205 Bailey Hall, Lawrence, Kansas 66045.)

Getting Started:

Begin in one of two ways, either choose a module which relates to a topic you plan to teach or find a science career person who is willing to come to your class. If you want to begin by choosing a module, look at the Table of Contents which lists approximately three main topics for each module. After choosing a module, look at the module's first page which briefly describes each activity in the module and the primary types of resource people to be used. The module's second page suggests how to contact a resource person for that particular module. (General suggestions for contacting resource people are contained later in the teacher's guide.)

Do not become overly concerned about finding exactly the resource person described for that module. While it is certainly preferable to find, for example, a metallurgist to use the lesson on heat properties of metals, people in science careers often have a diverse background and can use activities from any of several different modules as a basis for their visit. For instance, although it was not the authors' idea, in one class a nurse taught a lesson on symbiosis, using lichen as an example, and then went on to point out examples of symbiosis involving humans and the necessity of a broad science training prior to entering nursing. To our delight, the resource person's visit was quite successful for all involved. (Page two of each module describes related modules which could be taught by the resource people listed for that module and/or which focus on related topics.)

If you begin by finding a resource person, then skim through the Table of Contents to find a module particularly related to the topics covered in your course. After picking out the module and resource person, proceed as described previously under "How COMETS Works."

Finding Resource People:

Each module makes suggestions for finding resource people particularly appropriate for that module. The suggestions in the box which continues on the next page, however, apply across all modules.

Finding Resource People

- Inventory your students' parents' careers early in the school year. Match those in science-related careers with COMETS modules.
- Contact your counselor, career education specialist, and/or principal. Some districts have lists of resource people; but even if such a list is not available, these people can make referrals.
- Call on the Chamber of Commerce which lists local businesses, industries, and professionals. When available, a formal school/community career education committee can help in making contacts.
- Engage former students, either those from your own teaching experience and/or graduates of the district. Especially seek out alums now in collegiate science majors and ask them to visit your class during their school holiday.
- Enlist the aid of friends, especially those whose occupation provides broad community contact. Ministers, small business owners, and real estate people, for instance, often have this knowledge.
- Write or call a college or university. Contact either a science department and/or a public relations or admissions office. Faculty or students could be used as resource people. Most colleges view such visits as part of their service responsibilities; and in some cases, colleges already have a procedure for facilitating classroom visits.
- Consult the phone book yellow pages, especially to find professional people such as veterinarians, particular industries such as chemicals, or governmental agencies such as a highway department.
- Talk with professional acquaintances (such as your dentist). They may serve as resource people or refer you to others.

- Look within your own district. For instance, a school nurse, dietician, or computer specialist may be used as a resource person. Science teachers from higher grades may visit younger students, serving both as resource people and as recruiters for their classes. (That's not bad. One excellent technique for encouraging students to continue in science and math is for teachers to provide that encouragement directly.)

- Consider any producers of a product in your community. Engineers, the most numerous of science career people, are frequently employed there. If nothing else, most product producers test their products and thus apply science concepts. For example, a local dairy will have a lab where chemical and biological testing procedures are used.

- Contact organizations of science professionals (e.g., a county medical society) or clubs interested in science hobbies (e.g., garden, ham radio, computer, birding, or wilderness clubs). Some of these clubs can be found through a store (e.g., where computers are sold) or a library which may have a list of clubs and/or could tell you who is interested in books in a particular area.

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- Build a web of contacts. Ask each person for additional references.

- After every successful visit, smooth the way for a return visit in subsequent years.

- Enlist the aide of your students. Early adolescents enjoy and profit from taking responsibility and need the opportunity to learn to make new contacts in the community.

- In some cases a volunteer, such as a retired teacher or parent, may assist in contacting resource people. You and your students benefit along with the volunteer who has a chance to make a contribution.

- Finally, don't become discouraged. Finding appropriate resource people is perhaps the most difficult part of using COMETS.

Working With Resource People:

Contact your resource people well ahead of their visits. It's difficult to turn down a thoughtful and considerate request made several weeks in advance; plus, time for advance planning will make the visit more successful. After an introductory phone call, meet with them to enlarge on the purpose of their visit, to mutually select a COMETS activity to use in their visit, and to plan the activity. Plan the time and length of their visit and the activities related to the visit that you will do with students prior to and following the visit. Check what materials you and the resource person will provide. Discuss with them procedural issues such as where to park and how to find your class or meeting place.

If you feel the resource person is expressing any uncertainty about working with early adolescents, give them some hints you've found useful and assure them of your presence and assistance during the visit. Describe any special features of your students and classroom.

After the visit send a formal thank you, with a copy to their supervisor, if appropriate. (Check with resource people about whether they wish you to contact their supervisor. For some, such a contact will be helpful; but for a few, such a contact would be counterproductive.) Pave the way for a return visit. (If you feel good about their visit, the resource person probably does also and will be willing to repeat the activity.)

Alternative Uses of COMETS:

•Already we have mentioned that Profiles are available and can be used with COMETS Science activities or by themselves.

•A resource person may want to use an activity not described in COMETS. That's fine. COMETS is designed to ease the resource visitor's use of a science activity during their visit. In some cases the resource person will already have an activity in mind.

•Resource people could be invited to an evening parent/student session. Such a plan not only involves parents in school activities but also enables parents to acquire career information. Since parents are so influential in career decisions of students, it is advantageous that parents see the career relevancy of further science and math study. Moreover, if resource people are engaged in nontraditional careers, parents can receive the message that similar nontraditional pursuits are available to their children.

•While COMETS is intended to be used in association with visits by resource people, the activities can be lead by teachers. Frequently, a resource person will use one of a module's activities, but a teacher could use extension activities, other activities from the same module, or activities from related modules. In the event that no resource person is used, the Profiles can provide a resource person on paper; and students can read about someone who makes career application of science concepts.

•COMETS activities could be used in a special, gifted program, although it is intended for a broader range of students.

•Special interest clubs could use COMETS activities. For instance, an after school photography club might use the Light and Sight module as a basis for one of their meetings. Scout or 4-H clubs might also use COMETS activities.

•Some schools plan minicourses or special activity days or periods. Thus, even when students are not formally enrolled in science, they may be able to enjoy a resource person's visit during one of these special times.

•Some professional science organizations undertake an active school visitation program to inform more people about their careers, to recruit prospective students to their career, and to provide a community service. Organizations could use COMETS in planning their school visits.

Working With Others In the School:

Principals. It's important, especially if the use of resource people is novel, to discuss your plans with your administrator. Explain your purpose -- increase student interest in science and open new career options while teaching science subject matter. Regularly inform your administrator about specific visits and carry out any other procedures required in your school (e.g., register visitors).

Discuss with your principal using community resource people to not only improve science instruction but also enhance community support for the schools and their programs. Toward these dual goals -- improved instruction and enhanced relations -- your principal may provide special support such as helping make contacts with resource people.

Counselors. Enlist the aide of these important people in your project. They may be able to assist in finding resource people. In any event, they should be aware that students may seek science career information related to the particular resource person's career. Assist counselors in providing this information by sharing the bibliography about careers at the end of each module. If not already available, suggest that Exploring Careers (cited earlier) be made readily accessable to students.

Librarians. Perhaps this person and/or the counselor could make a special display of relevant career and related materials. A bibliography of biographies and autobiographies selected for early adolescents about women in science careers can be given the librarian to make these books available. Our experience suggests that books about men in science are readily available; but books about women in science are circulated to a lesser extent, so a bibliography describing these latter books is contained in the appendices.

Parents. As mentioned previously, a parent/student program or programs could be planned to include resource people who can use the COMETS activities just as they would if only students were present. Even if such a program is not planned, parents can be involved in encouraging their children's interest in science and math. A message home via the school's usual communications procedure could alert parents to the science career activities for the year. Parents might be informed of the materials listed in the various modules and appended bibliography and encouraged to provide these materials when their children express an interest and/or to whet student interest. Parents could also help their children find the empty cans, old newspapers, string, and so forth which are called for in some activities, thus saving the resource person and teacher much effort. Parents may volunteer to make initial contacts with resource people. Finally, parents themselves can be an excellent source of resource people.

Why Bring Resource People to the Classroom?

For many reasons. Probably most importantly, resource people are experts in topics included in science courses. They are expert *both* in the science topics *and* in the career (their own career) being presented to students. By bringing experts to class, your students can hear "straight from the horse's mouth" how the science they are studying can be applied and about science-related careers.

Visits from resource people provide a refreshing change of pace in instruction. No matter how well a teacher weaves together lectures, labs, demonstrations, films, discussions, and so forth, the resource person introduces additional variety needed for successful instruction of early adolescents.

Finally, resource people also serve as career role models to early adolescents who are becoming more realistic about career choices while leaving the "I want to be a sports star" fantasy stage of career choice. But why be concerned about providing role models? The answer is that one justifiable goal of instruction is to broaden the adult life options of students. That goal translates in the science classroom to encouraging students to consider how they might use science in a career both for their personal benefit and for the benefit of society. However, despite the best intentions of teachers and others, broadening the range of science careers considered by students is frustrated by students' being unable to conceive of themselves in careers other than those with which they are personally familiar. It is no accident that just as genetic traits "run in the family," so also do careers "run in the family" -- for instance, some families have lots of educators, others include several physicians, and still others are heavily involved in business. The occupational family traits, of course, do not result from genes, but rather from experiences available to growing children in their families -- they see people like themselves doing certain things, and they consciously or (more likely) unconsciously emulate those adults. Thus, if students' career options are to be broadened, besides adults in their own families, adolescents must see adults who in many ways are like themselves (e.g., same sex or race) in a broad range of careers. A judiciously selected cross section of adult resource people may become role models for students who discover by observing resource people, "Hey, I could do that!"

Career Oriented Modules to Explore Topics in Science

TOPICS		RESOURCE PEOPLE
Force Simple Machines Center of Gravity		Civil Engineer Mechanical Engineer Pilot

Constructions

THIS MODULE

Activity I

"Forces" is a brief activity requiring only a paper clip for each pair of students, who make and test a simple machine (a wheel and axle) out of the clip. This activity introduces the idea that simple machines are used to reduce (or change the direction of) force needed to do work, but that there is a trade-off in that the force must be exerted through a greater distance. Some additional illustrations of simple machines are suggested. Civil and mechanical engineers would make good resource people for this activity. Mention the work of Alva Matthews here or in Activity III (see "Women and Construction").

Activity II

In "Buildings" students are challenged to make bridges, towers, cranes, or observation platforms out of straws, tongue depressors, and pins. No other equipment is required. The majority of this construction work should be done outside of class. Resource people can relate these straw constructions to their own work. The architectural and engineering accomplishments of Julia Morgan in building William Randolph Hearst's palatial monument, San Simeon, should be related (see "Women and Construction").

Activity III

"Center of Gravity" is a series of short activities which demonstrates the effect of center of gravity on motion and shows how to locate center of gravity. Engineers or pilots could serve as resource people. Simple materials are used.

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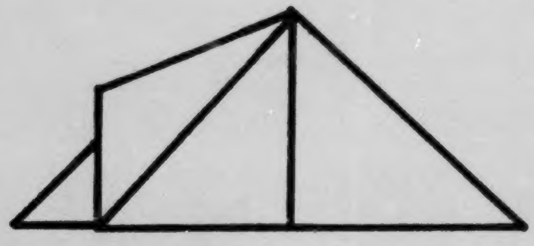


RELATED MODULES

Constructions is intended for career people who use basic mechanical concepts -- work, force, center of gravity, and so forth. Civil and mechanical engineers are two obvious groups of resource people. Architects, pilots and other engineers could also serve in that capacity.

Electrically Speaking

Students do simple activities with electricity production and circuits.

Energy

Concepts of producing, transferring, and conserving energy are the focus.

Misc. Materials

Crystals and characteristics of materials are studied.

Product Improvement

A fascinating material, "Glurch," and other materials are studied to learn how chemists, chemical engineers, and related career people produce desired products.

Through the Air

Properties of air and flight are taught by pilots and aeronautical engineers as resource people.

WHERE TO FIND RESOURCE PEOPLE

Civil engineers are frequently associated with private consulting firms, governmental public works departments (e.g., highways), and construction/contracting companies. Look in the yellow pages under construction. Mechanical engineers primarily work in manufacturing areas, making such things as machinery, transportation equipment, or electrical equipment. Look for places which make or maintain engines, refrigeration equipment, tools or presses. Vocational and technical school faculty could be resource people or they may refer you to civil and mechanical engineers. Professional and private pilots and flight instructors can be contacted through a local airport or flight school. Contact the engineering department of a nearby university.

A

Women and Construction

To build a twentieth century palace requires not only vast sums of money and a grandiose vision, which William Randolph Hearst, the San Francisco publisher, had, but also someone to plan and supervise the construction. That's what the architect and engineer, Julia Morgan, did. Between Hearst and Morgan, San Simeon, probably America's grandest private home and now a state monument, was built.

To fulfill Hearst's dreams not just any architect would do. San Simeon needed someone who could both draw up the plans for an aesthetically pleasing setting for Hearst's art and entertaining and also ensure its proper construction. And this wasn't just any construction job; this construction job was to take place over 150 miles from San Francisco in rugged terrain which at that time was not served by adequate roads. What was needed was someone who was both an architect and a civil engineer.

Julia Morgan had considered careers ranging from medicine to music but settled on architecture. However, at that time her school, the University of California at Berkeley, did not offer architecture, so she majored in engineering and received her degree in 1894. This basic grounding in engineering was vital to her subsequent success. After Berkeley she went to Paris and received her architectural degree from the Ecole de Beaux Arts, another fortuitous event because it provided her a classical background emphasizing large-scale elegance.

For many years, Hearst and Morgan worked together. In 1919-1921 she changed his dreams into the reality of three "guest houses," La Casa del Mar (The House of the Sea), La Casa del Monte (The House of the Mountains), and La Casa Del Sol (The House of the Sun); and in 1925 the main castle, La Casa Grande, was occupied. To give some idea of the scope of this project, consider that Julia Morgan had to design a harbor for the delivery of concrete and other building materials. Just one guesthouse, La Casa del Sol, has eight bedrooms, eight bathrooms, and two living rooms. La Casa Grande features two Spanish Renaissance towers, each 137 feet tall with 36 bronze carillon bells. The Assembly Room (living room) is 84' x 32' and 22' high. The Refectory (dining room) can comfortably seat 30 guests at one table in opulence. The Roman Pool (an indoor, salt-water swimming pool) measures 84' x 40'. And on and on 100 rooms parade before your eyes. (See Ken Murray's The Golden Days of San Simeon, Garden City, New York: Doubleday, 1971, for splendid pictures of this elegant estate.)

Whether one agrees with how Hearst chose to spend his money, the accomplishments of Julia Morgan can be admired. Her design of San Simeon can be related when doing Activity II, "Buildings."

While Morgan worked on designing structures, another woman, Alva Matthews, worked on basic research in construction. Her work focused on concepts with exotic sounding names like "dynamic impact loads, pressure wave propagation, and vibrations in elastic media." As this writing is taking place one week following the shocking collapse of two walkways in a Kansas City hotel, killing 111 and injuring scores more, Matthews' abstract sounding research takes on very practical, poignant meaning. What she studied was the effect of stress on a structure; and the results of her study aid understanding of structures like those walkways.

As an illustration of Alva Matthews' work, consider a company of soldiers standing on a suspension bridge. That's one thing, but compare that to the same soldiers marching across the bridge. As any veteran can attest to, soldiers "break step" (i.e., purposely get out of step) when marching across a bridge; because if they continued to march in cadence, at each footfall a shock wave, capable of weakening the bridge, would be sent through the structure. Many of us wonder, but don't yet know, whether the rhythmic movement of dancers on the hotel walkways produced a series of shockwaves which were propagated through the walkways to their supports which pulled loose.

Matthews' work can be related to the study of waves. If one end of a rope is attached and the other end is shaken up and down, the whole rope shakes up and down. Obviously the hand of the shaker does not move along the entire length of the rope lifting and dropping the rope. Rather, what moves (i.e., is propagated through the rope) is the effect of the initial shake. This movement of the effect of a force is referred to as a wave.

As your students study the various activities in this module, you can relate to them how Alva Matthew's area of study is aimed at understanding forces and how the effect of forces move through a structure. By better understanding this wavelike movement of the effect of forces through a structure, potentially better structures can be built.

Activity I: Forces

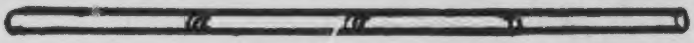
Materials:

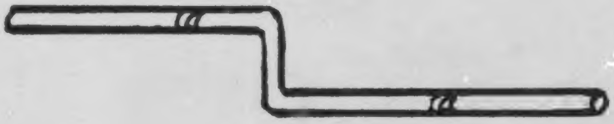
- One paper clip for each two students.

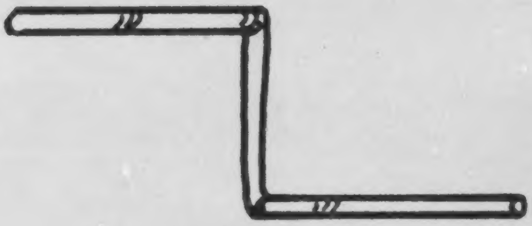
Procedure:

"Forces" is intended for the resource person who requires a very brief, uncomplicated demonstration of simple machines. Civil and mechanical engineers make particularly good resource people for this activity.

Pass out a paper clip to each pair of students and ask them to bend their clips out straight. Direct each student to grasp the paper clip as tightly as possible between thumb and forefinger. While one member of the pair holds tightly, the second member should attempt to roll the paper clip out of the other person's grasp. Next, make the paper clip into a crank. Again one member should grasp the paper clip, trying to keep it from twisting. The second member should attempt to turn the clip within the first person's grasp. Finally, the paper clip should be bent into a bigger crank by lengthening the middle section of the crank. Repeat the process of one student attempting to turn the clip within the grasp of the second student.





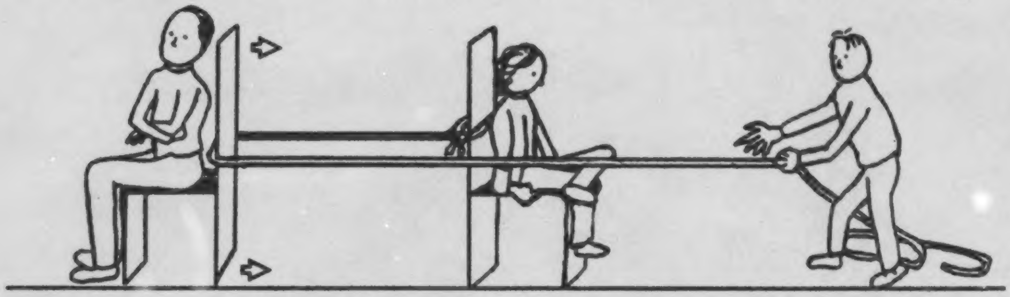


After the students have done this activity, ask them which shape of the clip made twisting easier. (The last arrangement, without doubt, should have been easier.) Ask students to observe again what they did and to figure out in which case the twister had to move the clip further in order to rotate the clip one revolution in the second student's fingers. (In the last case, where twisting was easier, the twister had to crank further. The general principle is that as the twisting became easier, the cranking distance became greater.)

Explain to the students that they have been using a simple machine, the wheel and axle. Simple machines do not really reduce the amount of work needed to accomplish some task; but simple machines do reduce the force (or change the direction of force) needed to do a given amount of work. However, there's a trade-off. In return for less force, the distance through which this force has to be exerted is increased. This relationship of work, force, and distance can be expressed by a mathematical formula:

Work = Force times distance or $W = Fd$

At this point resource people could turn to describing their use of simple machines or the concepts of work and force. Alternatively, before turning to their own careers, they may choose to show students additional examples of simple machines such as a can opener (lever), screwdriver (wheel and axle -- have students attempt to twist a screw into wood with a large and a small screwdriver), splitting wedge (wedge), screw (the threads are an inclined plane wrapped around the screw -- demonstrate this by wrapping a paper incline plane around a pencil), or a pully. A pully can be made by placing two ladder backed chairs back to back about six feet apart. Tie rope to one chair back and wrap it around the second chair. Have a smaller student sit in the chair to which the rope is tied and a somewhat larger student in the chair around which the rope is wrapped. Stand next to the chair to which the rope is tied and pull on the rope. The larger student will



move. Have observing students compare the distance the chair moves with the distance the rope is pulled through your hands. (You should pull the rope twice as far as the chair moves. To do the work -- i.e., move the chair and student -- using less force, the force -- i.e., pulling on the rope -- had to be exerted through a greater distance. Again, a simple machine doesn't reduce work, it only trades a decrease in force for an increase in distance.)

Activity II: Buildings

Materials:

- Soda straws (plastic are better than paper type).
- String to be used only for hanging weights.
- Straight pins.
- Tongue depressors or popsicle sticks.
- Hanging weights (fishing weights or metal washers work well).
- No tape, glue, or paper clips should be used.
- COMETS Challenge Cards (optional).

Use of This Activity:

This activity can take quite a lot of time and therefore probably should be done outside class time and prior to the resource person's visit. One good way to use this activity is to run a contest to make the best bridge (or other specified structure) and have the structures judged like a science fair. Prizes could be given for longest span (with no weights added), span that can hold the most weight, most efficient span (most weight held per straw), most symmetrical, most aesthetically pleasing, and so forth. Every bridge which could support a reasonable, set amount of weight could win a ribbon. This activity might also be connected with an art lesson in symmetry or in design.

In connection with an awards ceremony, resource people could relate the construction to their own careers. The contest construction (e.g., bridge or tower) should be chosen to relate to the resource person's career.

Procedure:

Have students use the materials provided to build one or more of the following structures. Demonstrate how straws can be connected with pins. Remind them of tinker toy or erector set structures they may have made. The tasks could be given to students as Challenge Cards. Directions could be modified if you choose to hold a competition.

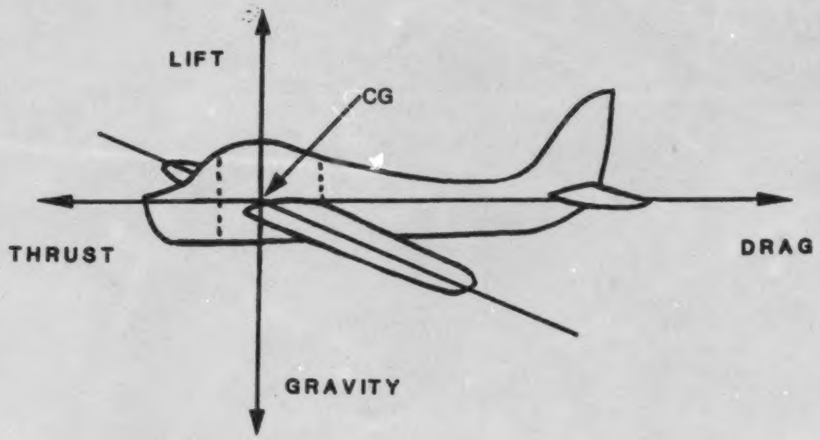
- Build a bridge at least 18" long, no more than 12" high, and able to support one pound hung from the center.
- Build a tower three feet tall and able to support one half pound hung from the top of the tower.
- Build a crane two feet tall with a side arm 9" long and able to hold one fourth pound hung from the side arm.
- Build an observation platform two feet tall with an observation deck nearly as wide and long as the base and able to hold one fourth pound at any corner of the observation deck.

Activity III: Center of Gravity

Introduction:

This activity is written as a combination of brief mind capturing illustrations of center of gravity, a technique for calculating center of gravity, and some extended applications of center of gravity. A resource person wishing a brief activity could use one of the suggested brief activities. A teacher and/or the resource person could then do some or all of the longer activities which go beyond a somewhat superficial introduction of center of gravity.

This activity could be led by a civil or mechanical engineer or by an airplane pilot who must be aware of center of gravity when preparing a plane for flight. A plane is designed so that when it is loaded with passengers luggage, fuel, and so forth, the center of gravity will fall within a specific area of the plane. If the plane is improperly loaded, it becomes imbalanced and difficult to fly. (See Extension Activity 2, "A Drunken Can," for an illustration of motion affected by a misplaced center of gravity.)



Brief Activity 1: Falling Boxes

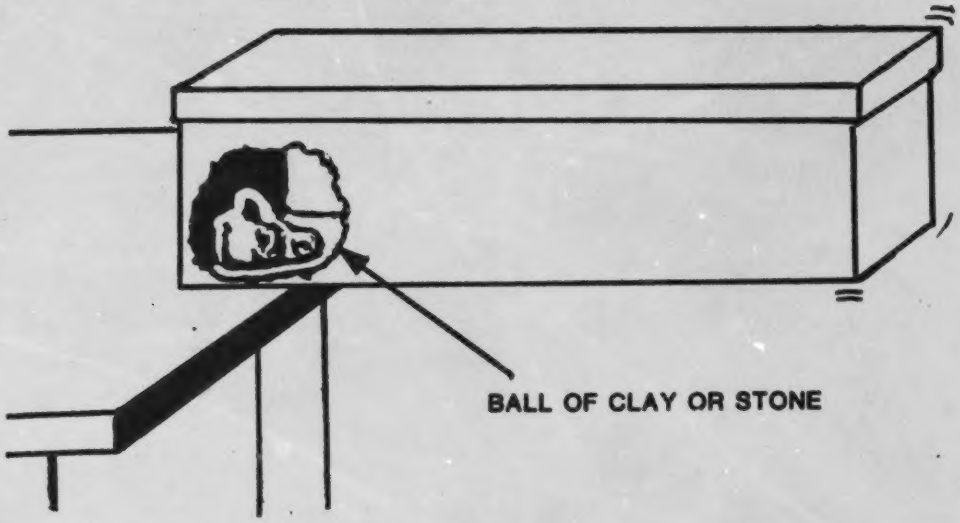
Materials:

- Empty box (e.g., cereal box) large enough to be seen easily.
- Stone or ball of clay.

A

Procedure:

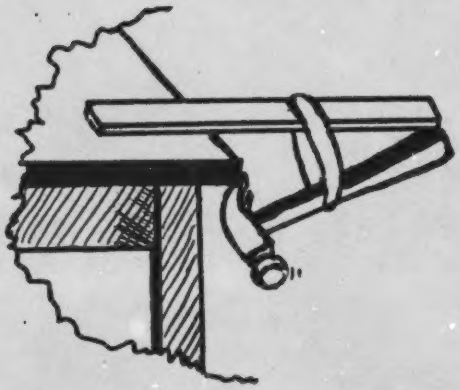
Place the clay in the bottom corner of the box and close the box. Before students enter the classroom balance the box on the edge of a table where it can be seen. As students enter, the resource person should stand close to the box so students' attention is drawn to it. The resource person should begin by having students speculate about why the box does not fall. Then center of gravity should be related to the person's career.

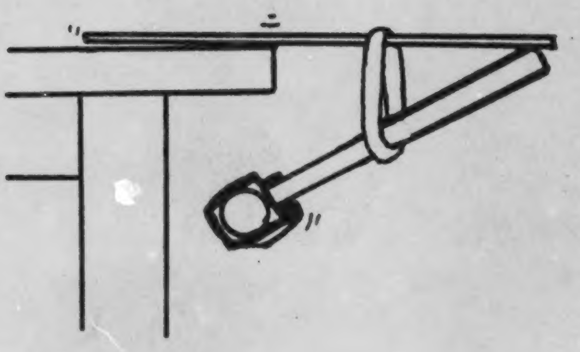


Brief Activity 2: Magic Hammer

Materials:

- Hammer.
- Stiff ruler.
- Heavy rubber band.





Procedure:

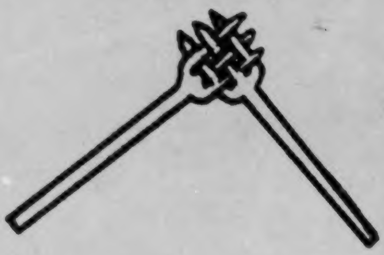
The resource person should wrap the ends of the hammer and ruler together with a rubber band, as shown in the illustration, and then balance this combination on the edge of a table. The resource person or a student volunteer can gently tap on the end of the hammer handle and rock the combination without the combination falling. The resource person should relate this activity to their career.

Brief Activity 3: Balanced Forks

Materials:

- Two plastic forks.
- Toothpick.
- Forks and toothpicks for all students (optional).

Procedure:



Interlace the tines of the fork as shown in the illustration. The forks can be balanced on a toothpick on the edge of a finger, table, or glass. (The toothpick is not stabbed into the forks, fingers, or any other object!) Having shown students that the forks can be balanced, you may choose to pass out forks and toothpicks and challenge students to duplicate the feat. Ask them to observe where the forks' weight seems to be centered when they are balanced.

Following this activity, center of gravity should be related to its career application by the resource person.

A

Main Activity: Finding Center of Gravity

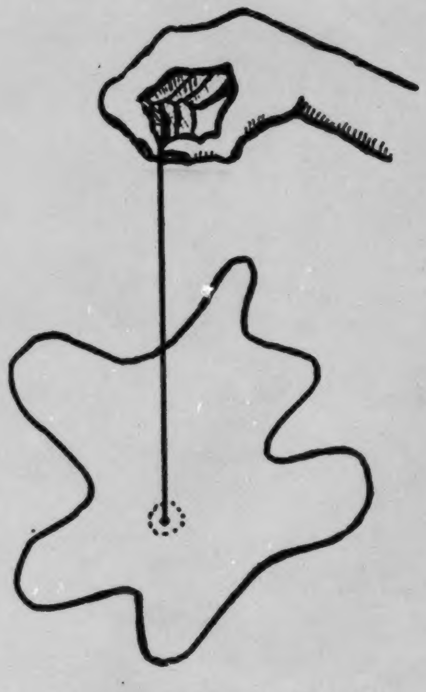
Material:

- For each student a piece of irregularly-shaped cardboard or poster board.
- Object (such as a ballpoint pen) to poke holes in the poster board.
- String.
- Button, washer, fasterner, or similar object.

Procedure:

In symmetrically shaped objects the center of gravity can be visually sighted by noting where the lines of symmetry meet. However, finding the center of gravity (i.e., the balance point) in an irregularly shaped object is more difficult. The resource person can show students the following procedure for finding the center for gravity.

The students should poke a hole in their cardboard somewhere off-center, but not too close to the edge. String can be attached to the hole by, for example, tying the string to a button and passing the other end of the string through the hole. Allow the cardboard to slide down the string until it is stopped by the button. Hold the string, as shown in the illustration, allowing the cardboard to hang freely. Draw a line on the cardboard along the string. Repeat this process with a new off-center hole, drawing a line along the string. The place where the two lines cross is the center of gravity.



The center of gravity of an object is the spot at which the object balances; all of the object's weight is evenly distributed around that point. Students can check the center of gravity they found by repeating the process a third time. Allowing for some experimental error, this third line should pass through the center of gravity previously found. As a final check, they could poke a hole at the center of gravity they found and balance the cardboard on the end of a pen struck through the hole. The cardboard should not rotate of its own accord about that point.

Extension Activity 1: Mobiles

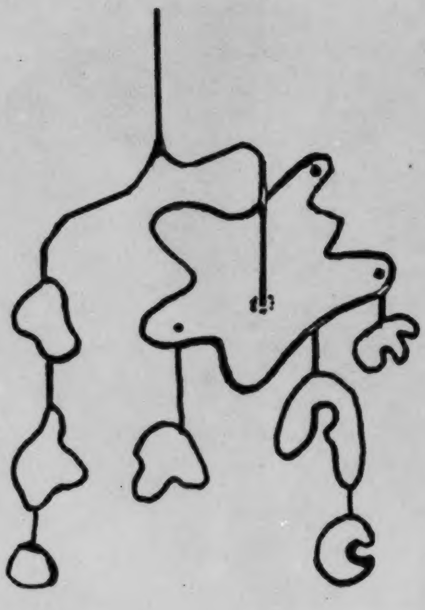
Materials:

- Coat hanger bent out straight, cut to different lengths (6" - 18"), and with ends bent back to be more blunt (and to provide a place for tying string).
- Irregularly shaped piece of cardboard, such as the piece used in the preceding activity.
- Pliers (for working with wire).
- String.
- Assorted objects of varying sizes and shapes to be hung by string.

Procedure:

Have students make a mobile with many more objects on one side than the other, but with the wires all horizontal and with the irregularly shaped piece substituted for one of the wires. Ask students some of these questions.

- Do the objects on each side of the balance have to be equal in weight?
- If the weights are uneven, how can you get the wire to balance?
- Where is the center of gravity of the entire mobile?
- Where is the center of gravity of each part of the mobile?



Extension Activity 2: A Drunken Can

Materials:

- Two coffee cans or gallon cans from the cafeteria with tops and bottoms removed.
- Two equal sized balls of clay (about one pound each).

Procedure:

Prepare two identical cans. Pack a ball of clay at a single location on the inside wall of one can. For the second can, divide the clay into many little pieces and pack these pieces evenly around the can's inside wall. Hold a can in each hand and roll them across the floor. Compare the motion of the two cans. In terms of center of gravity, account for the differences in motion. (The can with many little pieces of clay has a center of gravity very close to the axis of the can, so it rolls smoothly. The can with one ball of clay has a center of gravity quite distant from the can's axis. Thus, the can is almost always off balance, giving it a wobbly, jerky motion as it rolls.)

Career Information

Civil engineers, 155,000 strong, work in the area of engineering concerned with building and maintaining large structures. In antiquity civil engineers constructed the pyramids, Hanging Gardens of Babylon, Parthenon, Roman aqueducts, and Coliseum. Civil engineers were instrumental in the design and construction of modern structures such as the Golden Gate Bridge, Hoover Dam, Suez Canal, Eiffel Tower, Sears Tower (America's tallest building), and 50,000 miles of Interstate Highways. Of course, most civil engineers work with less spectacular structures, such as new schools, hospitals, shopping centers, manufacturing plants, roads, apartment buildings, and so forth.

Most of the 200,000 mechanical engineers work in manufacturing. An outgrowth of the industrial revolution, mechanical engineers design, supervise the construction of, and maintain turbines, engines, motors, lathes, presses, air conditioners and so forth.

Both civil and mechanical engineers, like all other engineers, can work in a variety of specific tasks, including research, design, supervision, sales, maintenance, quality control, education, and so forth. See Product Improvement and other related modules for more career information about engineering.

Related Activities:

Cherrier, Francois. Fascinating Experiments in Physics. New York: Sterling Publishing Co., 1979. Gorgeously illustrated experiments with forces and many other physics concepts.

Lodewijk, T. The Way Things Work: An Illustrated Encyclopedia of Technology, Special Edition For Young People. New York: Simon and Schuster. 1973. The operation of many fascinating things from automatic transmissions to zippers is described.

Senior Balancing and Structures. Published by McGraw-Hill Book Company, 1221 Avenue of the Americas, New York, New York 10020. Suggests activities dealing with forces and other concepts in mechanics.

COMETS Profiles:

Margaret Drake: Mechanical Engineer.
Her special interest is thermal science; and as a result she devotes much time to consulting on energy use.

Mary McGhee: Sanitary Engineer.
Chemical wastes and environmental protection are two focuses of her work.

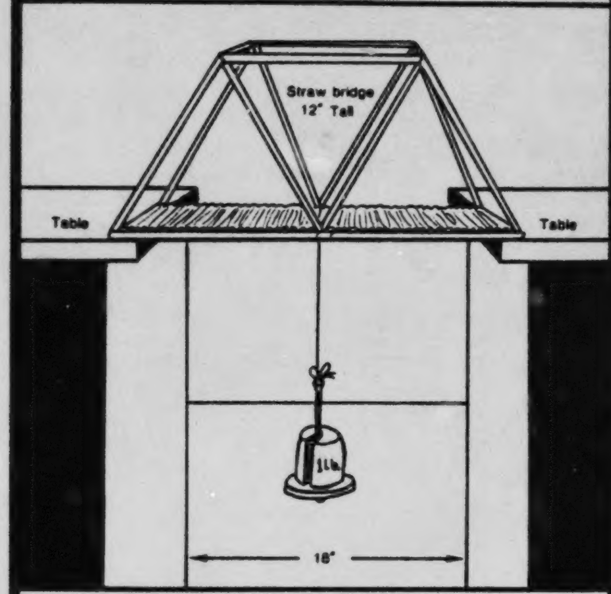
For More Career Information Write:

American Society of Civil Engineers, 345 E. 47th Street, New York, New York 10017.

American Society of Mechanical Engineers, 345 E. 47th Street, New York, New York 10017.

Society of Woman Engineers, 345 E. 47th Street, New York, New York 10017.

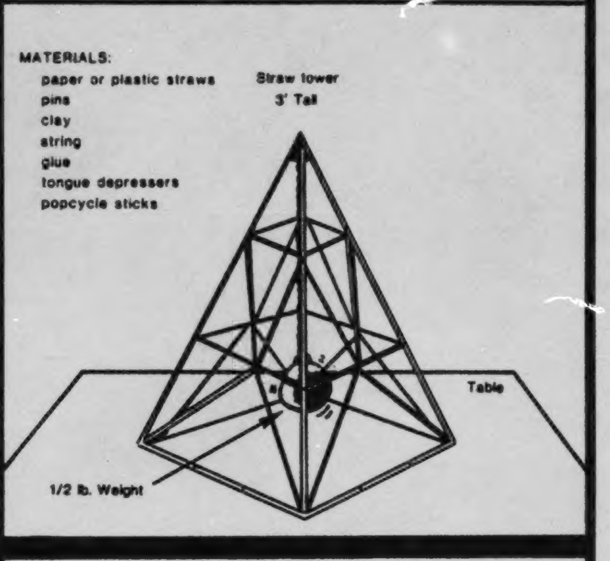
COMETS Challenge Card


Straw bridge
12" Tall
Table
Table
1lb.
18"

Constructions

Build a bridge 18" long, no more than 12" high, and able to support a one pound weight hung from the center.

COMETS Challenge Card


MATERIALS:

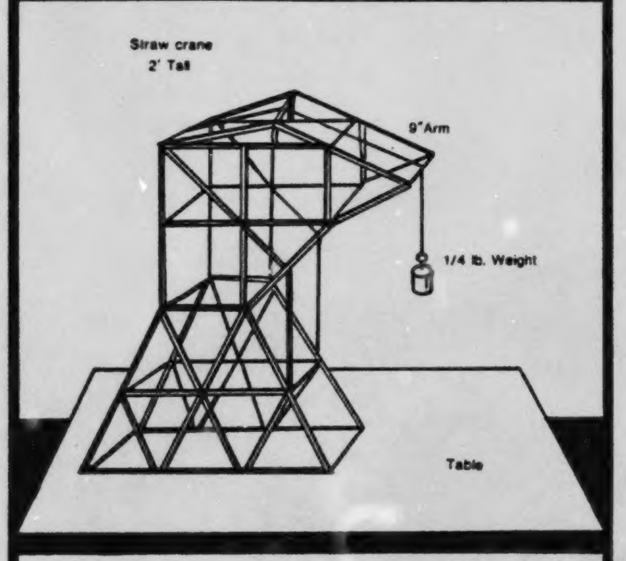
- paper or plastic straws
- pins
- clay
- string
- glue
- tongue depressers
- popcycle sticks

Straw tower
3' Tall
Table
1/2 lb. Weight

Constructions

Build a tower three ft. tall and able to support a one-half pound weight hung from the top.

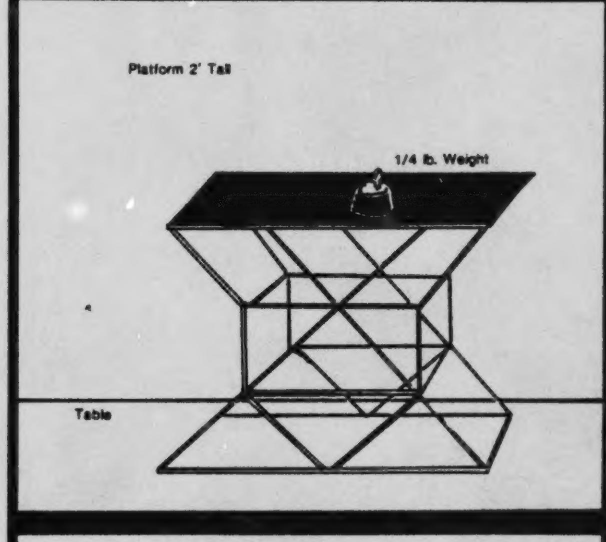
COMETS Challenge Card


Straw crane
2' Tall
9" Arm
1/4 lb. Weight
Table

Constructions

Build a crane 2 feet tall, with side arm 9" long and able to hold a one- fourth pound weight.

COMETS Challenge Card


Platform 2' Tall
1/4 lb. Weight
Table

Constructions

Build an observation tower 2 feet tall with an observation deck (almost as wide and long as the tower's base), able to support a one-fourth pound weight.

Career Oriented Modules to COMETS Explore Topics in Science

TOPICS

- Electricity
- Magnetism
- Energy

Electrically Speaking

RESOURCE PEOPLE

- Electrical Engineer
- Electrician
- Appliance Repairer

THIS MODULE

Activity I

In "Making Electricity Chemically" students assemble a chemical battery and an electricity detector (galvanometer) which is used in several places in this module. Directions for making a battery out of a lemon are also included. The materials are simple, but some collecting will be necessary. Students should exercise caution when using bleach. The activity can be brief, if done as a demonstration. Electrical engineers would be good resource people. The chemical production of electricity in flashlights and car batteries should be pointed out.

Activity II

In "Electricity ⇄ Magnetism" students learn that electricity can be used to produce magnetism (here in an electromagnet; with a galvanometer in Activity I) and that magnetism can be used to produce electricity (here by passing a magnet through a coil of wire attached to an electricity detector). This latter process is used in power plants to generate electricity. As in the first activity, simple materials are used but they must be collected. The activity can be brief, if done as a demonstration. Electrical engineers would be particularly appropriate resource people.

Activity III

Whereas the first two activities deal centrally with producing electricity, this activity, "Moving Electricity," focuses on series and parallel circuits. Challenge Cards direct student investigations. Again, the gathering of fairly simple materials is required. The work of Mildred Dresselhaus can be related here. Appliance repairers and electricians, as well as electrical engineers, would be good resource people.

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RELATED MODULES

Electrical engineers, electricians, and appliance repairers, who are the primary resource people for this module, may also be used in connection with these other modules.

Energy

Students study methods of capturing solar energy, using insulation to preserve energy, and moving energy by conduction, convection, and radiation.

Misc. Materials

In these activities intended primarily for metallurgists, students study properties of crystals, metals, and caramel.

Product Improvement

Students make "Glurch," a fascinating colloid, and paper with the emphasis on an engineer's work to make products to do specified jobs.

WHERE TO FIND RESOURCE PEOPLE

Contact a local electrical power company, the phone company, or a manufacturer of electrical devices. These companies can be located through a Chamber of Commerce. Look in the yellow pages under electrician or repair-electrical appliances. Resource people could be found in vocational schools or universities. Stores selling TV's, vacuum cleaners, or any other electrical appliances should be able to refer you to repairers of these products. Radio and television stations employ people knowledgeable about electricity. The 4-H and Scouts both conduct electricity activities and may refer you to people who assist in this area. Contact a ham radio club through a seller of radio equipment, the police, or civil defense. The local building inspector's office may supply a resource person who inspects electrical construction. People knowledgeable about electricity are employed at military installations.

B

Women and Electricity

When asked, "Of what practical use is it?," one of the first scientists to work with electricity replied, "Of what practical use is a newborn baby?" That nineteenth century skeptic might also question the value of the work of Dr. Mildred Dresselhaus of Massachusetts Institute of Technology. Why cool materials to more than 450°F below zero just to see how they will behave? Why subject those materials to a magnetic force one hundred thousand times greater than the earth's own magnetic field just to see how they will act? And besides, who cares about gallium, germanium, selenium and other strange things? At one level, these questions must be answered simply, "We want to find the answers for their own sakes; we're curious." However, the doubter might be more satisfied to know that in Mildred Dresselhaus's field, solid state physics, where these feats are performed, her MIT research and the findings of others have rapidly and directly led to twentieth century electronic marvels, including the computer, calculator, hi-fi and stereo, television, radar, microwave oven, lasar, solar battery, and on and on. Words like transistor, semiconductor, integrated circuit, and chip have made their ways into our vocabulary. Virtually no part of our lives have been unaffected by the electronics revolution spawned from basic research in solid state physics. More rapidly than babies become adults, new discoveries are applied in homes, stores, doctors' offices, assembly lines, and so forth.

Of particular interest to solid state physicists like Mildred Dresselhaus is a group of materials which normally conduct electricity poorly. In their pure form, these semiconductors cannot conduct electricity; but through the strategic addition of minute amounts of impurities, these materials can conduct electricity, thus providing several advantages over conventional circuitry. Compared to conventional tubes, wires, and the like, solid state devices are smaller and lighter, so extreme miniaturization has been possible. For example, we can hold in our hand a gizmo that only a generation ago would have filled a large room and still could not have efficiently performed the complex mathematical tasks we now execute on our calculators. Solid state devices--transistors, integrated circuits, and the like--lose less energy as heat, so they are energy conservative and less expensive to operate. Since they are one solid object and work at cooler temperatures, they do not break as easily as vacuum tubes and wires, so they are more dependable and last longer. Solid state devices are quite adaptable to a variety of applications; and even though the devices are extremely complex, they can be more readily manufactured than vacuum tubes and similar devices. Therefore, they are cheaper; and the products of which they are components have become rather readily available to the general population.

In Activity III students work with conventional circuits--batteries, bulbs, wires, and so forth. They can conceive of the electric current they are studying as a stream of electrons moving through the wire, roughly as water moves through a pipe. The water stream, analogous to the electric current, is composed of water drops, analogous to the electrons. Materials like copper metal have excess electrons which can move through the wire when an electric potential is added to the wire, as when the wire is attached (in a circuit) to a battery.

Similarly, some materials in transistors also allow electrons to move through them. These so-called n-type materials (n stands for negative, the charge of the electrons) are made from semiconductors by adding specific impurities which provide the excess electrons to make up the current. Interestingly, however, a second type of materials in transistors (called p-type; p stands for positive) can be made from semiconductors by the addition of some different impurities. P-type materials and the wire which your students are investigating work in opposing ways. What flows through a p-type material is not excess electrons, but rather the lack of electrons!

How can that be? Think of a row of 100 light bulbs all turned off. They could be successively turned on one at a time, thus producing the sensation that light was being passed down the row from one bulb to the next. Now think of the same 100 bulbs all turned on, except that they are successively rapidly turned off. In this instance the sensation would be that a lack of light was being passed along the row. When conceiving of transistor materials, the n-type materials are analogous to the light being passed from one bulb to the next, whereas the p-type materials are analogous to the lack of light being passed along. Transistors are made of layers of p-type and n-type materials sandwiched together in various ways to amplify current, change alternating to direct current and vice versa, and do other jobs previously done by more cumbersome and expensive vacuum tubes.

B

Pinpointing the precise contributions made by Dr. Mildred Dresselhaus in the development of semiconductors is difficult. Rather, what she has done is accumulate a mass of solid state physics information, especially about the characteristics of materials used in transistors and so forth. In recognition of her work and her ability as an administrator, she has been appointed Director of M.I.T.'s Center of Material Science and Engineering. She has been honored by Hunter College, Radcliffe College, and the Society of Women Engineers; and she has held high level advisory positions with the National Science Foundation and the National Academy of Science. Furthermore, her reputation is worldwide. She has been called to visiting professorships in Israel, Brazil, Venezuela, and Japan, one of the world's primary producers of the very electronic devices to which her work has contributed.

Activity I: Making Electricity Chemically

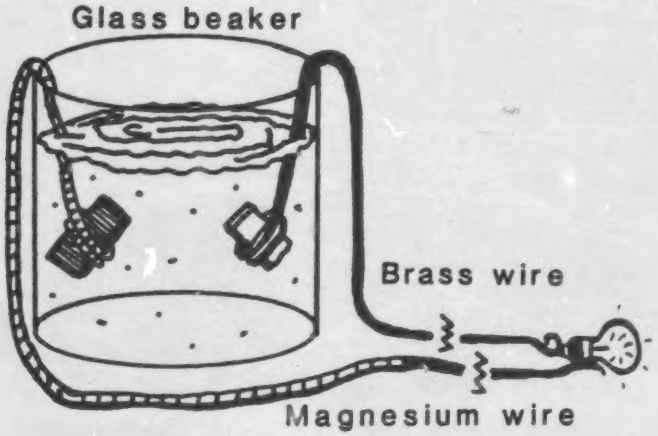
Materials:

- Magnesium ribbon (from high school science teacher).
- Copper or brass. Scrounge around in a junk box, strip insulation from wire and wind the wire into a coil, or talk to a high school science or industrial arts teacher.
- Household bleach.
- Wire (scraps from phone company or electrician).
- Glass jar or similar container.
- Flashlight bulb.
- Masking tape.

Procedure:

Your resource person could do this as a brief demonstration of how electricity can be produced in a chemical reaction. Ideally, each individual or small group would do the experiment, but that takes more time and equipment. Suggestions have been made above for sources of materials.

Ask students to make a chemical battery as shown in the illustration. Make sure all connections are made tightly. Masking tape may be used to hold wire in place. Students should be cautious in their use of bleach. Stirring the magnesium and copper (or brass) in the bleach may speed the reaction. If a lot of cloudy white deposit has built up on the magnesium, rub with sandpaper or steel wool to remove the deposit.



Have students observe the bulb lighting and any signs of chemical reaction in the jar. For example, they should be able to see gas bubbles forming. Point out that flashlight batteries also produce electricity by means of a chemical reaction. The electrician, electrical engineer, or other resource person should relate how they use these concepts in their careers.

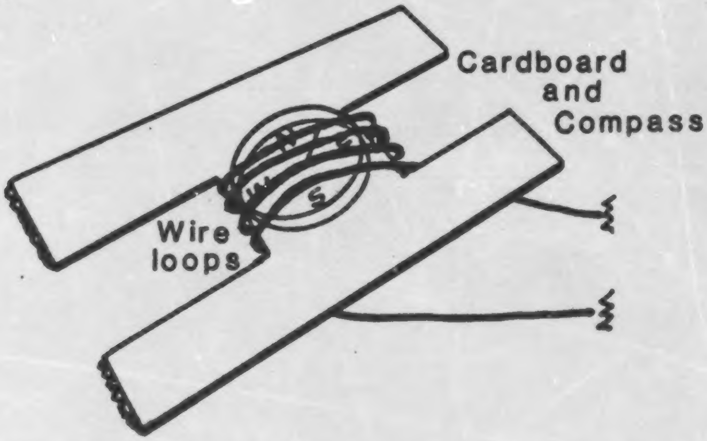
Extension Activity 1: Detecting Electricity

Materials:

- Cardboard.
- Compass.
- Wire.

Procedure:

An electric current produces a magnetic field, which can deflect a compass needle. This fact can be used to find out whether electricity is being produced in a particular situation (e.g., in Activity I). This application can be demonstrated by the resource person in connection with Activity I, or this activity could be done following the resource person's visit.



Current Detector

Have students make an electricity detector as shown in the illustration. The wire is wrapped several times around the compass and cardboard because with each wrap of the wire the electric circuit's magnetic field is increased. Thus, a weak electric current may be magnified sufficiently to be detected. This "electricity detector" is called a galvanometer.

Attach the galvanometer to the source to be tested for electricity production (for example, the chemical battery in Activity I). If the compass deflects, this indicates electricity has been produced. The greater the deflection, the greater the current causing the deflection. Reverse the connections of the galvanometer and note that the compass deflects in the opposite direction. The galvanometer can detect both direction and intensity of an electric current.

The galvanometer can be used to detect electricity coming from a flashlight battery. It is also used in other activities in this module.

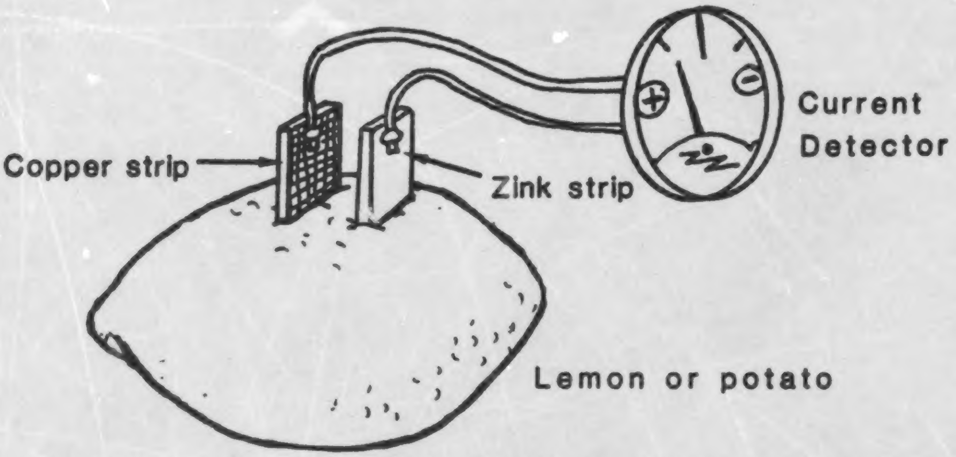
Extension Activity 2: Lemon Electricity

Materials:

- Lemon.
- Wire.
- Piece of copper metal.
- Piece of zinc metal (from high school science teacher).
- Electricity detector (galvanometer) from Extension Activity 1.

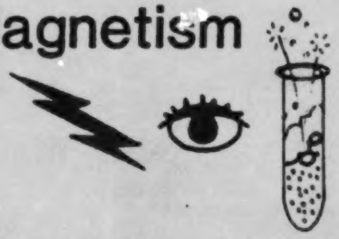
Procedure:

This is an alternative way of producing electricity by means of a chemical reaction. It can be done in addition to or instead of Activity I.



Make the lemon battery as shown in the illustration. To find out whether any electricity was made, attach the battery to an electricity detector (either a commercial galvanometer as shown here or a homemade detector like the one made in Extension Activity 1).

Activity II: Electricity ⇄ Magnetism

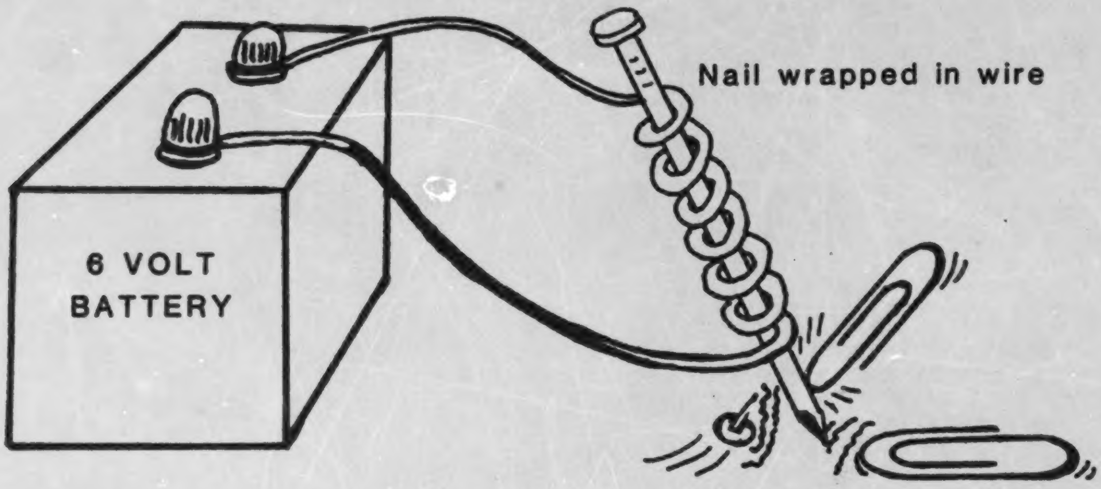


Materials:

- Nail.
- 6v battery (or other flashlight battery).
- Insulated wire.
- Tacks, paper clips, or iron filings (can be made by rubbing steel wool on a rough surface until it falls apart and collecting the pieces).

Procedure:

In Extension Activity 1 of Activity I, students made an electricity detector (i.e., a galvanometer). This same idea of using electricity to make a magnetic field is used on a larger scale to make a magnet (called an electromagnet, since it is made with electricity).



Wrap a wire several times around a nail and attach each end of the wire to a 6v battery. Touch the nail to a pile of tacks, paper clips, or iron filings. Next, have students see what happens when they do each of the following and touch their magnet to the tacks, paper clips, or iron filings.

- Double the number of turns of wire around the nail.
- Quadruple the number of turns.
- Remove the nail and insert a wooden pencil in its place.
- Vary the number of turns of wire around the pencil as was done with the nail, and compare these observations with those made with the nail.
- Remove the pencil and with just the coiled wire try to pick up the tacks, paper clips, or iron filings.

B

Have students compare their electromagnets with the galvanometers made in Extension Activity 1 of Activity I. They should realize that in each case they have used electricity to produce a magnetic field.

Extension Activity 1: Making Electricity Magnetically

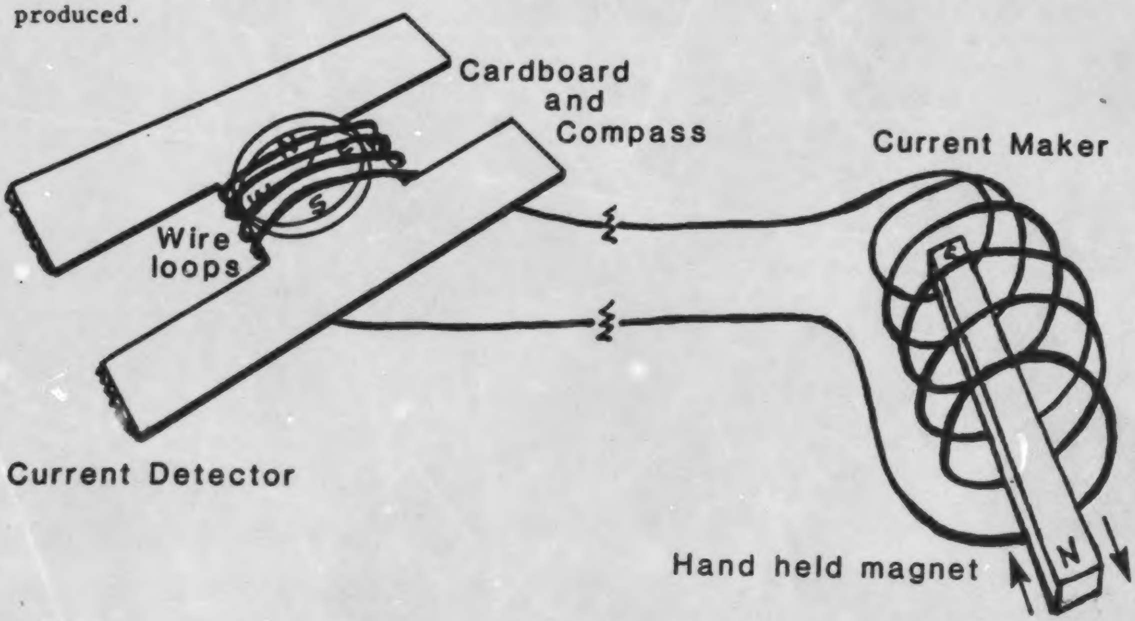
Materials:

- Strong magnet. (This could be an electromagnet from the preceding activity.)
- Wire.
- Electricity detector (galvanometer) from Extension Activity 1 in Activity I.

Procedure:

This activity could follow Activity I, in which case you should point out that electricity can be made not only from chemical reactions (as in Activity I) but also from magnetism. However, this activity could be done alone. It can be a brief demonstration as each student could individually do the activity.

Making electricity from chemical reactions is expensive, although that method can be quite useful (as in the flashlight or car battery). A less expensive way of producing a great deal of electricity takes advantage of the fact that when a wire cuts through a magnetic field, an electric current is produced.



Have students make a wire coil with a diameter large enough to pass a magnet through the coil. Attach this wire coil to the electricity detector. They should pass the magnet back and forth through the wire coil, noting which way the compass deflects on each pass. (It will deflect in opposite directions as the magnet is passed back and forth through the coil.) They should note whether moving the coil or the magnet makes a difference. (Which one moves relative to the student makes no difference; the movement of the wire relative to the magnet is what is important.)

The resource person or teacher should point out that this technique of generating electricity is used on a large scale wherever electricity is generated. Whether coal, nuclear, geothermal, or water power is used, that power source moves a magnet relative to a wire coil, thus generating electricity.

Finally, the students should note the relationship of electricity and magnetism. Each can be used to produce the other.

B

Activity III: Moving Electricity

Materials:

- D cell flashlight batteries (three per individual or group of students).
- Bulb and bulb holder (can be the bulb and reflector from a flashlight).
- Wire (scraps from electrician or phone company).
- Large rubber band or masking tape (for attaching wires).
- Challenge Cards (optional).

Procedure:

This activity can be condensed into a demonstration, but it probably will work better if done prior to a resource person's visit. Then the resource person could comment on it. This activity assumes that students have done some basic work with simple series circuits (i.e., they realize a complete circuit is needed).

Students can be given each or all Challenge Cards, or the activities suggested on the cards can be orally described. Here are some additional comments to supplement each card.

If a bulb and holder are not available, a flashlight bulb and reflector or just the bulb itself can be used. Use rubber bands or masking tape to attach wire to the bulb or bulb holder and batteries. If only the bulb is used, attach one end of the wire to the end tip of the bulb and the other wire to the side of the bulb. Caution: Bulbs get hot. In the first card which compares batteries in series (A) and parallel (B), bulb A lights more brightly.

On the second card, if switches A, B, or D are opened, the bulbs won't light. If C is opened but D is closed, the bulb will light. A simple "switch" can be made by just touching two wires together.

When more batteries are added in series (A versus B on the third card), nothing happens to the bulb's brightness. However, as more batteries are added in parallel (C versus D), the bulb becomes brighter.

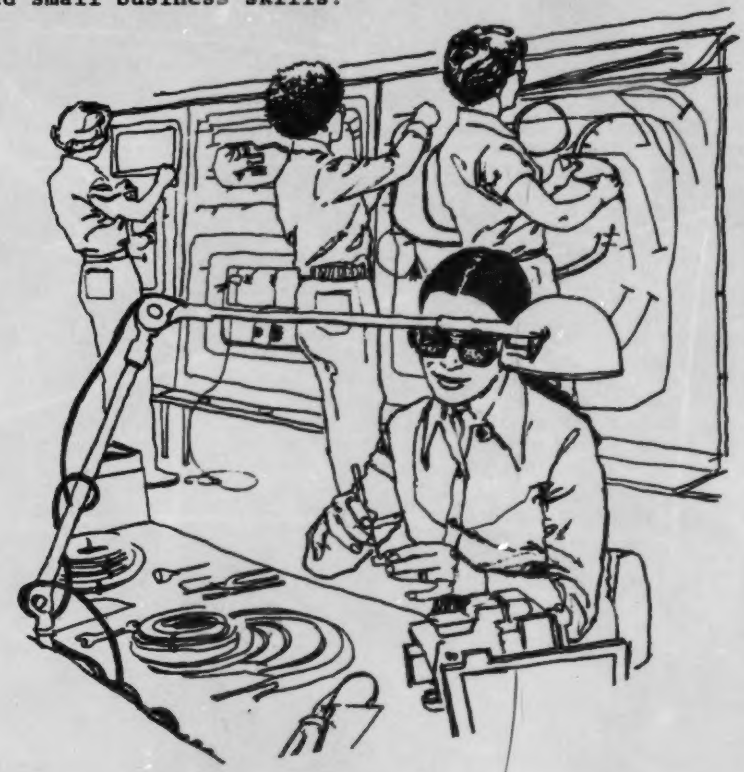
Finally, when an additional bulb is added in series (A versus B on the fourth card), the first bulb dims. However, when the second bulb is added in parallel (A versus C), the brightness of the first bulb is unaffected. In both cases, when two bulbs are in the circuit, their brightness is equal.

Career Information

The electronic ignition for a car, a hair dryer, a dimmer switch for the dining room lights, and over 30,00 other products are made in the electronics industry, a giant growth industry of the twentieth century. Electrical engineering with 300,000 practitioners is the largest specialty in engineering. Another 300.000 people are involved in maintenance of electrical equipment, and nearly that number work in electrical construction. These nearly one million career people do not include many thousands more in manufacturing of electrical and electronics devices.

Electrical engineers work in the power industry and in the design, manufacturing, and use of electrical equipment. As is described in Product Improvement for all engineers, the electrical engineer must have a strong math and science background and an undergraduate engineering degree.

Electrical construction and maintenance workers receive their training in apprenticeship programs of approximately four years and/or on the job, at vocational schools, or in the armed forces. In some locations licenses are needed before full entry into the field. Many electricians are self-employed, so they need small business skills.



Related Activities:

Batteries and Bulbs. Available from McGraw-Hill, 1221 Avenue of the Americas, New York, New York 10020.
A teacher's guide for initial electricity experiments.

Ortleb and Cadice. Electricity. St. Louis: Milliken.
A series of transparencies for teaching electricity concepts.

Schultz, Robert F. Edison Experiments. Detroit: Thomas Alva Edison Foundation, 2000 Second Avenue, 48226. 1969.
This and several other interesting pamphlets are available.

A World for Women in Engineering. A highly recommended movie available free from your nearest Bell Telephone office.

COMETS Profiles:

Donna Geisler: Engineer.
As an engineer for the phone company, this woman must use her knowledge about electricity daily on the firing line.

Janice Morgan: Telephone Installation Supervisor.
Installing phones is much more than learning to climb poles, as Janice Morgan's Profile reveals.

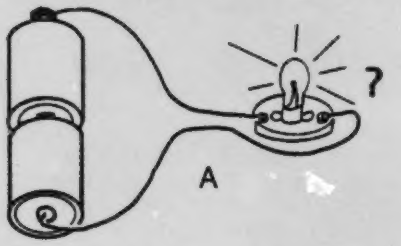
For More Career Information Write:

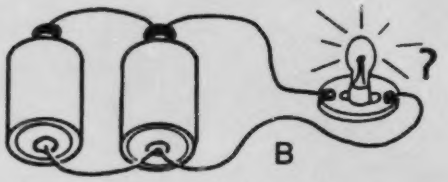
Associated Independent Electrical Contractors of America, 1201 N. Watson Rd., Suite 201, Arlington, Texas 70611.

Institute of Electrical and Electronics Engineers/United States Activities Board, 1111 19th St., N.W., Washington, D.C. 20036.

A nearby university which trains engineers.

COMETS Challenge Card

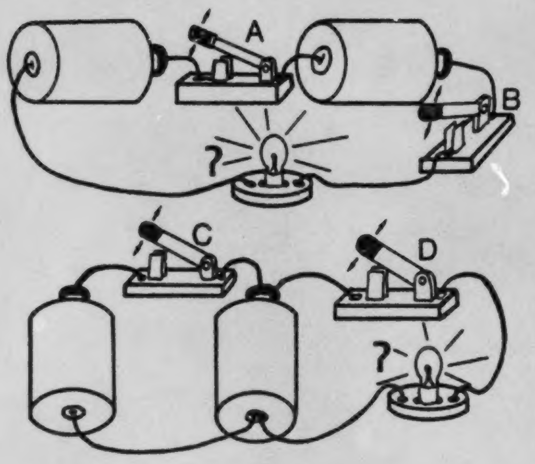




Electrically Speaking

Which bulb is brighter, A or B?

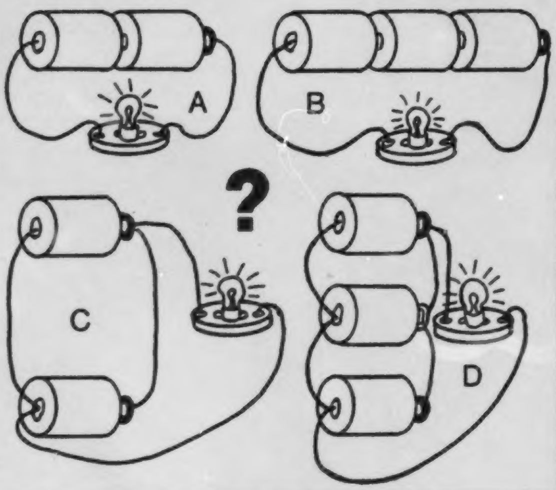
COMETS Challenge Card



Electrically Speaking

What will happen to the bulb if you open switch A with switch B closed? B with A closed? C with D closed? D with C closed?

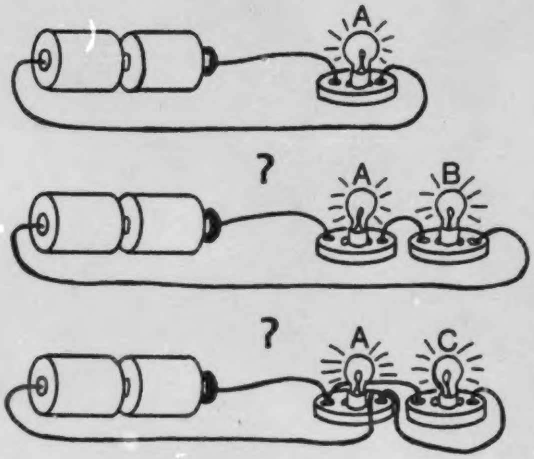
COMETS Challenge Card



Electrically Speaking

What happens to the bulb when you add more batteries in a series (A vs. B)? In parallel (C vs. D)?

COMETS Challenge Card



Electrically Speaking

What happens to bulb A when bulb B is added in series? When bulb C is added in parallel?

Career Oriented Modules to COMETS Explore Topics in Science

Energy

TOPICS	RESOURCE PEOPLE
Energy Production	Mechanical Engineer
Energy Transfer	Industrial Designer
Energy Conservation	Solar Builder

THIS MODULE

Activity I

Students make solar cookers in "Producing Energy" to learn how solar energy can be collected with a parabolic mirror and converted to heat energy for some useful purpose (such as making a cookie treat). Fairly simple materials are used, but extensive preparation of the solar cookers is required and the activity itself takes some time. This activity would relate well to a resource person who uses solar energy concepts. The work of Meitner and Mayer in atomic energy (see "Women and Energy") can be mentioned in this activity.

Activity II

"Moving Heat" begins with a brief activity using simple equipment, but requiring some advance preparation, to demonstrate radiation, conduction, and convection as means of transferring energy. In a longer extension activity, "Retarding Heat Movement," students investigate insulation, using Challenge Cards. The extension activity also teaches experimental process skills such as identifying and operationally defining variables. Mechanical engineers are good resource people for this activity.

Activity III

In "Retaining Heat" students explore the capacity of materials to absorb or transmit energy. This extended activity requires equipment such as a heat source and thermometers. As in Activity II, students collect and interpret data, thus practicing experimental process skills.

University of Kansas School of Education Department of Curriculum and Instruction

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RELATED MODULES

Energy is intended for people in energy careers, including production, use, and conservation. People in the growing field of active or passive solar energy use could be invited to class to teach Activity I. Designers and architects must be particularly attuned to energy. All engineers use energy concepts in their careers, so those resource people could also visit the classroom in connection with several other modules. For instance, most engineers use probability, statistics, and graphing in some way, so they could use the modules, Chances Are and Figures Don't Lie. Following are modules particularly intended for various engineering specialities.

Constructions

Students study simple machines, force, center of gravity, and other concepts particularly useful to civil and mechanical engineers.

Electrically Speaking

Students do simple activities with electricity production and circuits.

Misc. Materials

Crystals and characteristics of materials are studied.

Product Improvement

A fascinating material, "Glurch," and other materials are studied to learn how chemists, chemical engineers, and related people produce desired products.

Through the Air

Properties of air and flight are taught by pilots and aeronautical engineers as resource people.

WHERE TO FIND RESOURCE PEOPLE

Contact the local power or public utility company. Architects can be found in the yellow pages. Mechanical engineers are employed in manufacturing industries. People interested in active and passive solar construction sometimes are featured in newspaper articles. They may also be found through local governmental offices which issue building permits. Look for governmental agencies such as the Department of Energy in the yellow pages. Contact a university engineering and/or physical science department for faculty members or students. Look in the yellow pages for energy career people under refrigeration, air conditioning, heating, and insulation. Contact the local Chamber of Commerce for assistance.

Women and Energy

Women have been particularly instrumental in unraveling the atom's secrets. Of course, Marie Curie, a discoverer of natural radioactivity, is probably the best known woman scientist. However, to her name on the list of women atomic scientists can be added her daughter, Irene Curie (synthesized artificial radioactive elements), Lise Meitner (introduced "nuclear fission" to our vocabulary), Maria Goeppert Mayer (uncovered the structure of the nucleus), Rosalind Yalow (applied radioactivity; see Body Detectives for more information), and Chien Shiung Wu (performed experiments on the behavior of atomic particles). This section is devoted to two of these women, Lise Meitner and Maria Goeppert Mayer, whose work is fundamental to our harnessing fission and fusion to generate energy.

Lise Meitner, an Austrian, worked in the frenzy of excited discovery that boiled in Europe in the early twentieth century. Imagine that in just four decades (from the discovery of radioactivity by Becquerel and the Curies in the 1890's to the discovery of atomic fission by Meitner and her colleagues in 1939), nuclear scientists had advanced knowledge of the atom from the first inkling of radiation's existence to the verge of the atomic bomb and subsequently its harnessing for energy production.

Meitner was working in Hitler's Germany with Otto Hahn on experiments which pointed the way to fission, when in 1938 she, a Jew, was forced to slip out of the country. Hahn continued the experiments but was puzzled by the results, so he sent his data to Meitner for her analysis. She pondered the evidence and concluded that the data could be explained only by assuming the atom had been split. With this modest announcement by Meitner and her cousin and collaborator, Otto Frisch, in the January 16, 1939, edition of Nature, the world learned about atomic fission: "It seems therefore possible that the uranium nucleus has only small stability of form and may, after neutron capture, divide itself into two nuclei of roughly equal size. The two nuclei will repel each other and should gain a total kinetic energy of 200 million electron volts."

While the immediate race was on to turn this tremendous energy source to war-time uses, Meitner steadfastly eschewed any connection with the bomb. In fact, she was quite indignant that anyone should see her as somehow authoring that destruction.

Lise Meitner was not the only scientist forced out of Hitler's Germany.

A virtual migration of brainpower was drained from German soil in the 1930's. Early in the decade, for less political reasons, Maria Goeppert Mayer and her new husband, an American, left Germany for Baltimore. Having studied with Born, Franck, and Fermi, all of whom received the Nobel Prize in physics for their nuclear research, during World War II Mayer joined the group of scientists working on various phases of the Manhattan Project which produced the atomic bomb. However, it was her postwar research on the structure of the atomic nucleus which led to Maria Goeppert Mayer's own Nobel.

Scientists had come to understand that electrons whirled around the atom in such a manner that rather than conceiving of their paths as orbits (like orbits of the planets), it would be more correct to think of electrons as moving in shells with their position at any time being indeterminate. However, the nucleus was conceived of as neutrons and protons which were in more or less fixed arrangements (sort of glued in place like popcorn in a popcorn ball). This notion, however, puzzled Mayer, because she knew that certain elements were rather impervious to atomic breakdown, while others could be artificially broken, and yet others broke down spontaneously. This situation of different degrees of susceptabilitiy to breakdown of the nucleus was analogous to different degrees of susceptability to chemical reactions. (Chemical reactions involve electrons which, remember, were thought of as existing in shells.) She reasoned that a conception of the nucleus as composed of protons and neutrons moving in shells (rather than sitting in one static lump) made more sense. Independently, Hans Jensen in Germany was arriving at this same idea of a nuclear shell theory. They then worked together leading to the 1955 publication of Elementary Theory of Nuclear Shell Theory and to the 1963 Nobel Prize in physics for both scientists.

The work of Lise Meitner and Maria Goeppert Mayer can be related to this module's Activity I, "Making Heat," which focuses on energy production. The connection between their research and the activity can be made in two ways. First, the solar cooker in Activity I isn't producing energy; it's capturing the sun's radiant energy. The sun's energy was produced by the sun's nuclear fusion process, our understanding of which relies on Mayer's explication of the nuclear shell theory. A second connection can be made in that Activity I shows one means of producing heat energy as an alternative to burning fossil fuels. Other alternative heat sources are the already available, controlled atomic fission process (to which Meitner contributed) and the potentially controlled atomic fusion process (to which Mayer contributed).

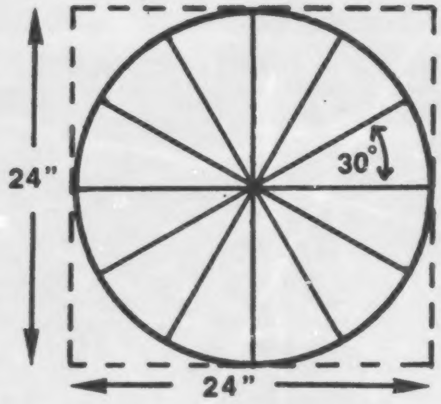
Activity I: Producing Heat

Materials for Solar Cooker:

- 24" x 24" piece of plywood (scrounge around).
- Six 8" x 24" pieces of cardboard.
- Construction paper.
- Aluminum foil.
- Glue.
- String.
- Coat hanger wire 15" long.

Directions for Making a Solar Cooker:

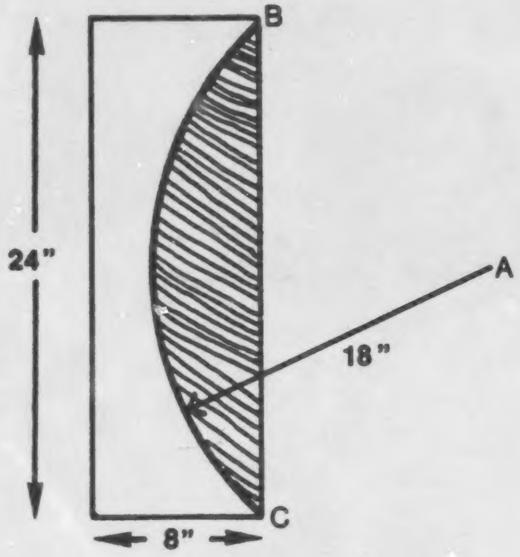
The base should be done by people skilled in the use of the power saw. This would be a good project for a high school woodworking class. For the base of the cooker, draw a circle with a radius of 12" on plywood. Draw two straight lines at right angles across the diameter of the circle, thus dividing the circle into four quadrants. Divide each quadrant into three equal pie-shaped pieces (see illustration). Next, use a power saw to cut grooves along the six lines drawn along the diameters.

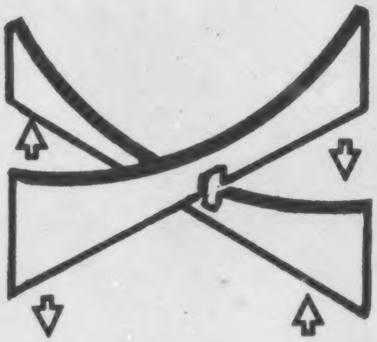


Activity I is based on "Solar Cookers" by Richard C. King from Science and Children, 18(7), April 1981, pp. 6-8.

C

For ribs in the cooker, draw and cut out sturdy cardboard pieces 8" x 24". To make a pattern for the ribs cut arc BC out of one of the long sides of the cardboard (see illustration). The radius of the circle making arc BC is 18". Hold an 18" string at A and draw arc BC; then cut out the shaded area. This pattern can be used for all other ribs. Six ribs are needed for each cooker.





Cut four of the ribs in half and slot the two full ribs to fit together (see illustration). Glue these ribs in the slots on the base at right angles. Glue the eight half ribs in the grooves with the narrower ends of the ribs all meeting at the center. The general shape of this framework of the cooker is a parabola. (See "Women and Graphs" in Figures Don't Lie for more information about parabolas.)

Next glue construction paper onto the ribs, working on every other section so that glue can dry while the work proceeds. The construction paper should be taut and conform to the parabolic shape. Once the glue dries, cover the construction paper with heavy duty aluminum foil with the shiny side up. To attach the foil, put glue on the construction paper, working on every other section and gently smooth the foil onto the glue with a tissue. To cover the area where the foil overlaps in the center, cut out a 4" diameter cardboard, cover it with foil, and glue it over the messy center. The parabolic, light collecting area of the cooker is now ready.

To make an aimer for the cooker, push a 15" coat hanger wire through the center of the mirror and attach it to one of the cardboard ribs. It is important that this wire be straight, so the mirror can be aimed.

Materials for Activity:

- Solar cooker.
- Coffee can painted black and with top removed.
- Coat hanger to make handle for coffee can.
- Tripod or other arrangement from which to hang can.
- Water.
- Thermometer.

Procedure:

This activity takes quite a bit of time, so it may work best as an out-of-class activity. It should be done prior to a resource person's visit and then commented on by the resource person.

Caution students about some possible dangers which grow out of the positive properties of the mirror. The mirror is focusing light from all parts of the mirror at a point approximately along the wire aimer. Watch for high temperatures. Keep eyes away from the focal point. Do not play around trying to aim the mirror at other students. Do not look directly at the sun.

After the mirrors are ready, students should learn to aim their mirrors. The temperature should be carefully checked along the wire aimer. Frequent adjustment is needed as the sun moves across the sky. Once the aiming technique has been developed, the temperature can be recorded and graphed at frequent intervals (say, each 15 minutes). Where classes meet in 45-60 minute periods, successive classes can take turns collecting data.

Next, a coffee can pot can be hung from a tripod (or other point such as the frame of a playground swing). The temperature of water in the pot can be measured and aiming adjustments made until a high temperature is reached. (Temperatures of roughly 170°F have been recorded on 70°F days.)

Once adjustments have been made to maximize the temperature in the coffee can, dry the can and make treats such as "s'mores" (marshmellow and chocolate melted in a graham cracker sandwich).

The work of Lise Meitner in atomic fission and Maria Goeppert Mayer in atomic fussion (see "Women and Energy") can be related here, since both solar and atomic energy are emerging energy sources.

C

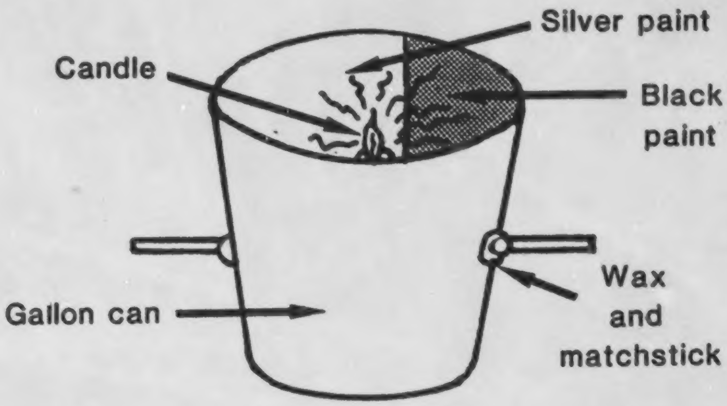
Activity II: Moving Heat

Materials:

- Gallon can with top cut off (available in most cafeterias).
- Candle (the leftover one from the last party).
- Two wooden matches or similar sized identical sticks.
- Black spray paint.

Advance Preparation:

Spray paint the inside of half the can and allow it to dry. Drip candle wax on the outside of the can over the black paint and on the opposite side of the can over the unpainted part.



Stand a wooden match in each glob of wax perpendicular to the can. The globs of wax holding up the matches should be equal in size. Allow the wax to dry so that the matches stand up on their own. Drip some wax in the bottom center of the can and stand the candle in this wax. The candle should be equidistant from both matches.

Procedure:

With only enough explanation to point out the can's construction, the resource person should light the candle and have students watch what happens. Very shortly the wooden match over the blackened part of the can will fall, followed by the match over the silvered part of the can. Discuss with students possible explanations. (Black absorbs radiant energy more readily than silver, which tends to reflect radiant energy. Since the blackened area absorbs heat more rapidly, the wax outside the blackened area melts more rapidly and that match falls first.)

Absorption of energy and transfer of energy by radiation, conduction, and convection (all of which are present in this demonstration) can be related by resource people to their careers. (The candle radiates energy; the metal conducts energy; and the hot air rises, an example of convection.)

Extension Activity 1: Retarding Heat Movement

Materials:

- Several gallon cans.
- Several smaller cans (e.g. soup or juice cans).
- Thermometers.
- Various insulation materials (e.g., styrofoam pellets used in packing, commercial fiberglass insulation, shredded newspaper, grass clippings, dirt, excelsior, feathers, shredded rags, or whatever can be found).
- Aluminim foil to cover the inside can (poke thermometer through foil).
- Hot and cold water.
- Newspapers to catch mess.
- Clock with second hand.
- Challenge Cards (optional).

Procedure:

This activity, which deals with insulation, can be done prior to the visit of the resource person, who could then comment on it and state its career applications. Because of its length, most resource people will be unable to work with students directly on it. Alternatively, this activity could follow the resource person's visit.

Following the illustrations and questions found in the COMETS Challenge Cards, students can conduct experiments involving the effect of one or more independent variables on the dependent variable, heat transfer. This activity provides an opportunity to study not only energy but also several experimental processes (e.g., identifying and operationally defining variables, collecting and graphing data, making inferences based on observations, and so forth).

Here are some problems that could be posed.

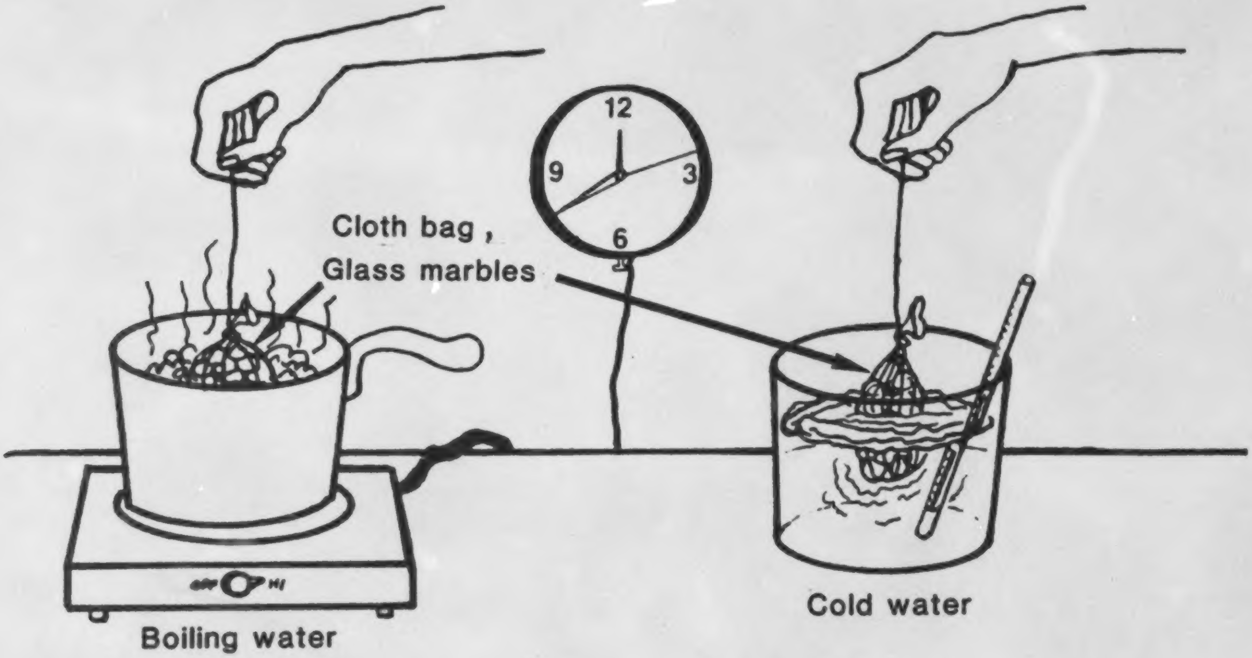
- Which insulates best? Try styrofoam, dirt, fiberglass, or any other potential insulators (see list of materials).

- Does packing insulation more tightly help or hinder a material's insulating ability? (Student should pack the insulation quite tightly and compare this with very loosely packed insulation. Ask them to consider down-filled jackets in relationship to their results.)
- Does the temperature rise or fall more quickly in an insulated container?
- Which insulating material provides the most insulation per dollar? (One way of defining insulation cost efficiency could be as minutes of heat retention per dollar. Have students measure how long it takes for the temperature of water to drop 10°F and divide this time by the cost of the surrounding insulation. Since most of the insulating materials will probably have been donated, finding the real cost of the materials will take some digging and computing. For example, find the size and cost of a truckload of fill dirt and compute the cost of the dirt in the can.)

Activity III: Retaining Heat

Materials for Each 1-3 Students:

- Styrofoam cups for cool and hot water (used coffee cups work well).
- Container in which to boil water.
- Hot plate or other heat source. Hot pads may be needed.
- Squares of cloth of the same material (about 3" x 3").
- String.
- Pieces of different kinds of materials of similar shape and size (e.g., coins, washers, wire, nuts, bolts, glass marbles, plastic or wooden beads, etc.).
- Thermometer.



Materials for Entire Class:

- Clock or watch with second hand (optional).
- Balance(s) or graduated cylinder(s).

Procedure:

This activity takes some time. Therefore, the resource person and teacher may choose to do it prior to the resource person's visit and comment on the activity or as a follow-up to the resource person's visit. Since some materials may be scarce, the activity could be done in a supervised learning center. The resource person or teacher should give the students a little background information. Some materials are better than others at absorbing and/or retaining energy. We can test materials for these properties.

Have students wrap some of each material in a cloth square and tie the cloth with enough string left over so that the bag can be dipped safely into a container of slowly boiling water. The amount of each material used should be equated in terms of mass (use a balance) or volume (use a graduated cylinder and measure volume displacement). After heating the objects in this way, each bag should be transferred to a container of cool water. The volume and initial temperature and succeeding temperatures of the water should be measured each 30 seconds until the temperature levels off. These data could be graphed (time on the horizontal axis and temperature on the vertical axis) and a line plotted for each material.

As an alternative procedure, place the bags of material at room temperature into containers of very hot water. The temperature of the water could again be collected and graphed.

In the first procedure, the students are measuring how rapidly the materials give up their heat energy to water. In the second case, absorption of heat energy by the materials is being measured.

After the experiment has been completed, discuss these questions with the students.

- How can you be sure that your end results were due only to the kind of material you used and nothing else?
- How much material should be used in each bag? Did it make a difference whether the metals were equated in mass or volume?
- Which material absorbed energy best? Which material was worst at absorbing energy?
- How did you define best or worst? Was it defined in terms of, for instance, how much energy could be absorbed (regardless of time) or how rapidly the energy could be absorbed?
- Did the materials work comparably for both properties (i.e., giving away and absorbing energy)?
- Would your findings have any implications for selecting materials for absorbing energy in a passive solar home, in making cooking utensils, or in designing machinery?

Career Information

What science career doesn't involve energy utilization in some way? All engineers use energy concepts. These careers are described in Constructions, Electrically Speaking, Misc. Materials, Product Improvement, and Through the Air. Geologists are needed to find new fuel sources, and that career is described in Soils. Architects and designers must design more energy efficient structures, and their careers are described in Third Dimension.

Related Activities:

Energy and Man's Environment (EME), 7874 W. Nimbus Avenue, Beaverton, Oregon, 97005.

Project for an Energy Enriched Curriculum (PEEC), c/o U. S. Department of Energy, Technical Information Center, P.O. Box 62, Oak Ridge, Tennessee 37830.

Science Activities in Education (SAE), c/o U. S. Department of Energy, Techincal Information Center, P.O. Box 62, Oak Ridge, Tennessee 37830

PEEC and SAE materials are available free of charge. EME materials are available at cost, or in some geographical areas some materials are free. Write EME, PEEC, and SAE for ordering information.

The Energy Challenge. c/o U. S. Department of Energy, Technical Information Center, P. O. Box 62. Oak Ridge, Tennessee 37830. A series of 24 activity spirit masters and teacher's guide about our energy past, present, and future for grades five to eight.

Career Information:

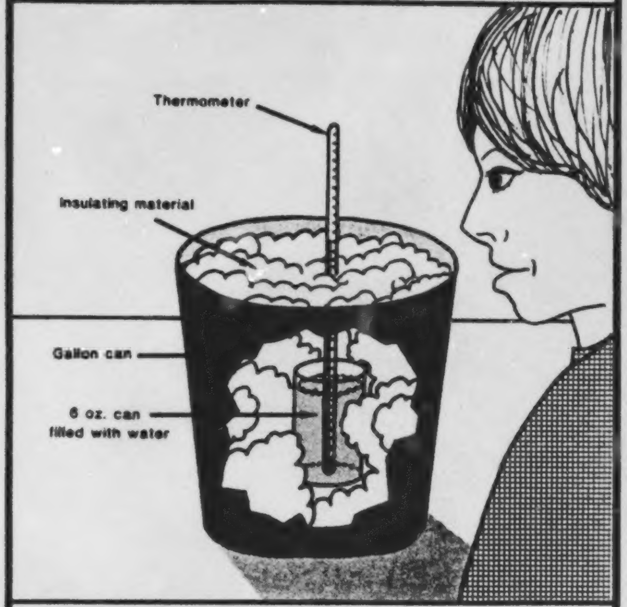
U.S. Department of Energy. Professional Energy Careers. Washington, D.C.: Author, Office of Public Affairs, 20585. 1979.

COMETS Profiles:

Margaret Drake: Mechanical Engineer.
Among other duties, Margaret Drake does consulting on problems of solar energy.

Marcia Turner: Architectural Engineer.
As energy costs grow, architects like Marcia Turner must consider energy use when planning new projects.

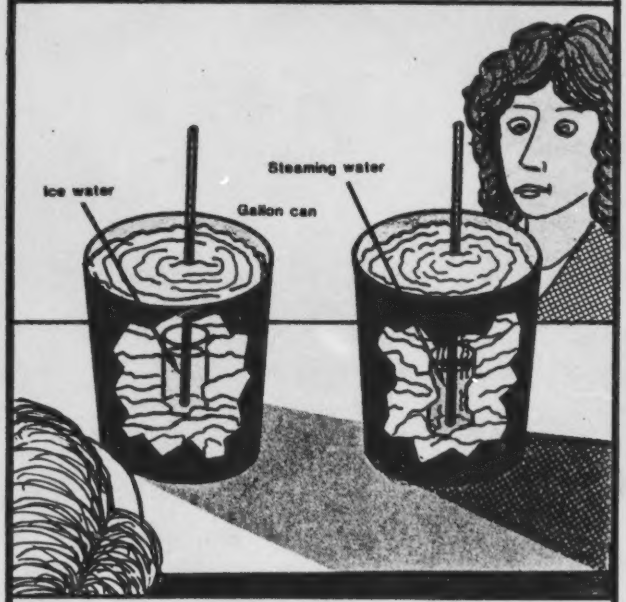
COMETS Challenge Card


Thermometer
Insulating material
Gallon can
6 oz. can filled with water

Energy

Which insulates best: styrofoam, dirt, air, fiberglass, or something else?

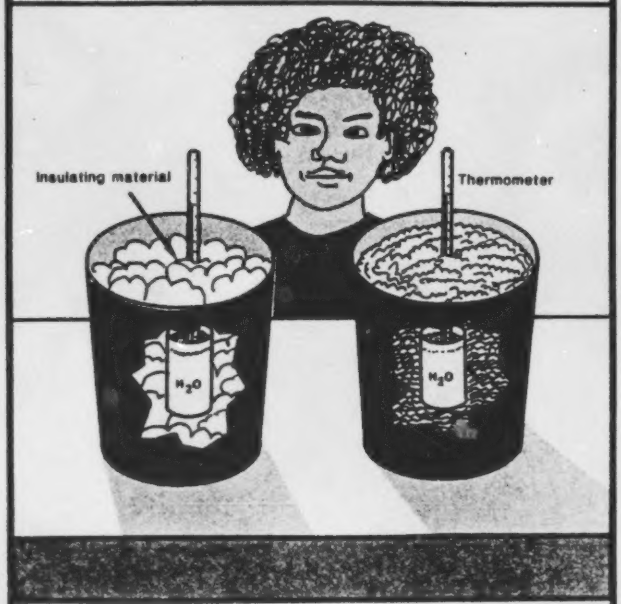
COMETS Challenge Card


Ice water
Gallon can
Steaming water

Energy

Does the temperature rise or fall more quickly?

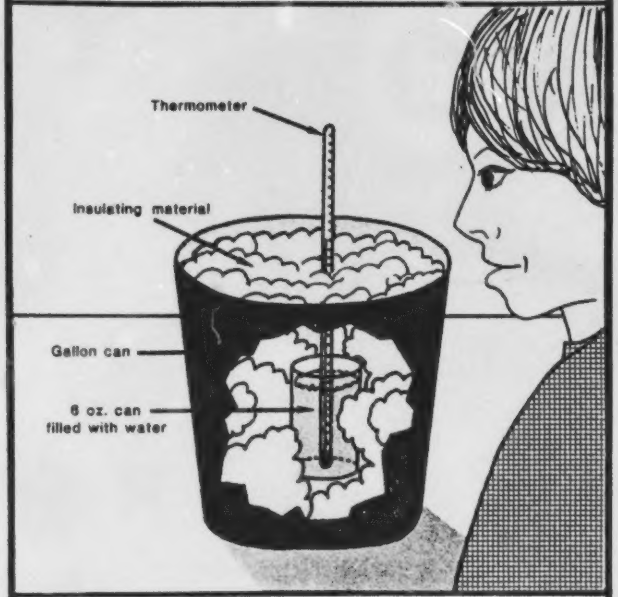
COMETS Challenge Card


Insulating material
Thermometer
H₂O
H₂O

Energy

Does packing insulation more tightly improve its insulating ability?

COMETS Challenge Card


Thermometer
Insulating material
Gallon can
6 oz. can filled with water

Energy

Which material gives you the most insulation per dollar?

Career Oriented Modules to Explore Topics in Science

Find Some Evidence

TOPICS

- Chemistry
- Classification
- Scientific Method

RESOURCE PEOPLE

- Detective
- Crime Lab Worker
- Chemist

THIS MODULE

Activity I

In a brief activity in "Fingerprints" students learn to classify fingerprints into three basic types, arch, whorl, and loop. In an extension activity students make their own fingerprints and apply fingerprint classification skills to picking the "guilty person" out of a group of 11 suspects. The main activity requires only the reproduction of a worksheet, but the extension activity requires some equipment. This activity would fit well in a unit on classification or scientific method, and many different people working in crime detection could be resource people.

Activity II

"Chemical Evidence" requires students to collect evidence about four known chemicals and then apply this evidence to the identification of unknown chemicals. This activity could be led by a crime lab worker or a chemist, even if the chemist works far afield from forensic science. Much equipment, all of it rather easily available, is required; and the activity should be done over at least two periods. The unit fits well in the study of chemistry. The work of Cathy Thomas (see "Women and Forensic Science") can be related here.

Activity III

"More Unknowns" applies the starch test introduced in Activity II and applies a test for salicylic acid introduced here. Some special equipment is needed and thus this activity might best be done as a demonstration. If the materials are prepared ahead of time, it can be a brief activity. A crime lab worker or chemist would be a good resource person, and the activity would fit well in a unit on chemistry. The work of Cathy Thomas (see "Women and Forensic Science") or Rosalind Yalow (see "Women and Body Detectives" in Body Detectives) could be related here.

University of Kansas   School of Education   Department of Curriculum and Instruction

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RELATED MODULES

This module is intended primarily for people working in crime detection, especially detectives, who can especially relate their use of the empirical scientific method to solve crimes, and crime lab workers, who can relate their use of chemistry. Other modules which may be used by these resource people include the following.

Body Detectives

A test for pH, using red cabbage juice, is used. Also, the work of Rosalind Yalow is described.

Pharmacy

Students learn about drug development and interaction, using concepts about which most chemists would be knowledgeable.

Information Manipulation

Classifcation methods are the focus of this module which serves as a prelude to working with computers.

Electrically Speaking

Chemical batteries are made and investigated by students.

Product Improvement

Students make a fascinating collodial product, "Glurch," and information about careers in chemistry is included.

WHERE TO FIND RESOURCE PEOPLE

Contact your local, county, regional, or state police force. Ask also for references to nearby crime laboratories, some of which are mobile and may be able to be taken to the school. The police department may also refer you to vocational and four year schools offering training in criminology and related fields. See Product Improvement for suggestions about where to find resource people in chemistry.

Women and Forensic Science

Cathy Thomas is a forensic scientist who specializes in serology, the analysis of body fluids, including blood, perspiration, saliva, and seminal fluid, which are among the principle sources of physical evidence used by police to solve crimes. As an undergraduate she majored in chemistry and biology; and in graduate school she started in biochemistry but turned to forensic science, a closely related field. She has taken postgraduate work at Scotland Yard, where the British have developed blood analysis procedures which can nearly distinguish one individual's blood from another's. Similarly they can categorize fingernails.

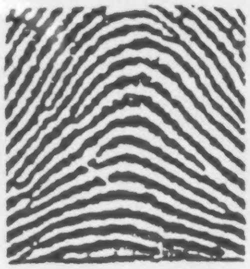
More crime labs are being built or expanded in recent years for several reasons. One, court decisions have limited the use of interrogation of suspects by police, so police have had to depend more heavily on physical evidence. Two, new crimes, such as drug trafficing, have appeared and require new techniques in their detection. Three, new, sophisticated chemical and physical analytical techniques, each requiring specialized training, have been developed. Finally, money for these laboratories has been made available to many local jurisdictions by the states and especially the federal government.

The crime lab employs some or all of a host of tests with exotic sounding names: ultraviolet and infrared spectrophotometry (see Light and Sight for information about how Annie Jump Cannon used similar information to classify stars), neutron activation analysis, gas chromatography, differential thermal analysis, and radioimmunoassay (see Body Detectives for information about Rosalind Yalow's development of this technique). These new techniques require that police also be more sophisticated in gathering evidence. Some larger forces are even employing evidence technicians who specialize in gathering physical evidence so that nothing is overlooked and so that the evidence is preserved in a form that can be tested in the lab. Cathy Thomas occasionally has been called to the site of a homicide to collect evidence. It's not a pretty scene, but one to which she has accustomed herself.

Cathy Thomas not only collects evidence and performs serological examinations but also testifies in court as an expert witness on her findings. Thus, the work of Cathy Thomas demonstrates the breadth and sophistication needed by the modern crime laboratory worker.

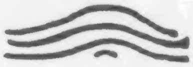
Worksheet 1

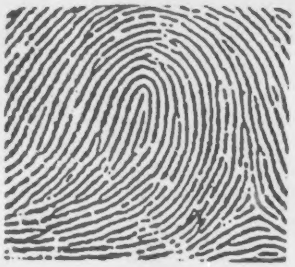
Three Basic Fingerprint Patterns



Arch

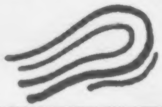
Ridges extend from one side of finger to the other and are slightly raised in the middle.

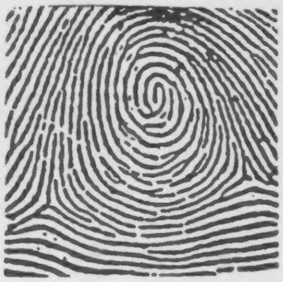




Loop

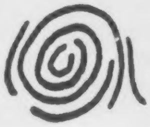
One or more ridges make a hairpin turn. Both ends of the loop generally end on the same side of finger.



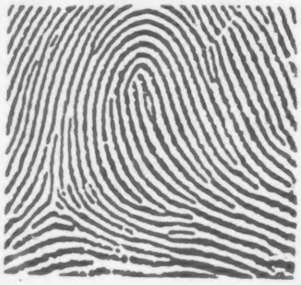


Whorl

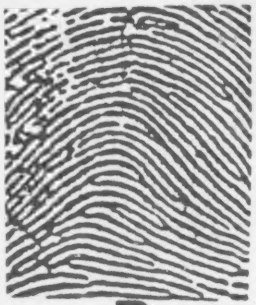
Ridge follows a spinning or circular pattern.



Which of the three basic patterns is each of these ?



A



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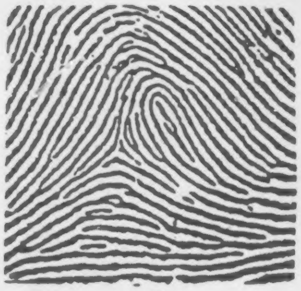

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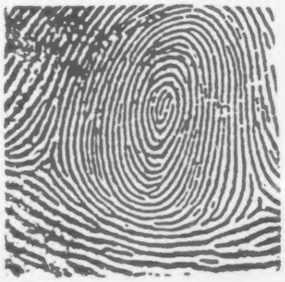

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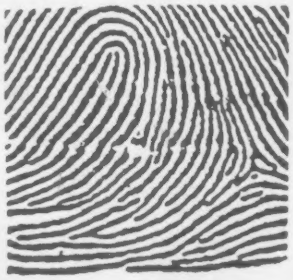

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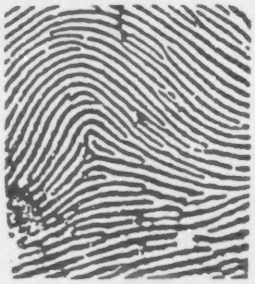


F

Activity I: Fingerprints

Materials:

- Copy of fingerprint worksheet, "Three Basic Fingerprint Patterns," for each student. (The worksheet appears on the preceding page.)

Procedure:

Forensic science relies on careful observation and classification and on use of an empirical, scientific approach to problem solving. A fundamental forensic science technique used in identification of people is fingerprint analysis. A resource person can use the worksheet to briefly explain the classification of fingerprints into three basic patterns. After describing the important distinguishing characteristics of the arch, loop, and whorl, have students classify each of the six unknown fingerprints into one of the three categories. Answers: A-loop; B-arch; C-loop; D-whorl; E-loop; and F-arch.

This activity is brief and thus will allow more time for talking about applications of the scientific method by career people in crime prevention. However, getting students involved in observing their own fingerprints can further heighten their interest, and that kind of activity is included in Extension Activity 1.

Extension Activity I: Fingerprints Applied

Materials:

- Art printmaking brayer, and
- Black water-soluble ink for block printing, and
- Smooth linoleum tile. (An inked stamp pad can be substituted for the brayer, ink, and tile.)
- Hand lens.
- Copy of "Who Opened the Refrigerator?" worksheet, which appears after page 8.
- Paper (with boxes for fingerprints of each finger and thumb, if possible).
- Rags for wiping off inked fingers.
- Soap and water.
- Newspaper.

D

Making Fingerprints - Brayer Method:

Spread a thin layer of black printing ink on the linoleum with the brayer. Students should roll the end of each of their fingers one at a time through the ink, getting ink on three sides of their fingers. Next, they should roll their fingers on the appropriate boxes of a worksheet similar to the illustration below (e.g., right little finger in box marked "right little"), getting an imprint of all three inked sides. They should press firmly but not so hard as to smudge the print, and they should make one steady roll of each finger. They should not roll the finger back over the original mark. Each student should work on one finger at a time, inking, imprinting, and wiping it off before proceeding to the next finger. They probably should practice their technique on scrap paper before proceeding to making a "good" set of prints.

Making Fingerprints - Stamp Pad Method:

This method is identical to the Brayer Method, except that students ink their fingers by rolling them over a well-inked (but not saturated) stamp pad. The results of this method are not quite so clear as with the Brayer Method, but stamp pads are more generally available and the prints are quite satisfactory for this activity.

Procedure:

This activity could be done after the resource person's visit. If this activity and Activity I are both to be done by the resource person, substantial time could be saved by students making their prints prior to the visit.

Make a print of each finger where indicated.

1. RIGHT THUMB	2. RIGHT INDEX	3. RIGHT MIDDLE	4. RIGHT RING	5. RIGHT LITTLE
6. LEFT THUMB	7. LEFT INDEX	8. LEFT MIDDLE	9. LEFT RING	10. LEFT LITTLE

Have each student make a set of their own fingerprints and an extra copy of their own right index finger. Have them classify each of their prints into one of the three basic patterns: arch, loop, or whorl. They may want to use a hand lens to help in the process. Since some prints may not clearly fall into one of the three categories, advise students not to be too concerned if they can't identify all their prints. Ask students:

- Do all of your fingers have the same basic fingerprint pattern?
- Do fingers on your left hand have the same pattern as identical fingers of the right hand? For example, if the right middle finger is a whorl, is the left middle finger also a whorl?
- If fingers on the right and left hand have the same pattern, is one the mirror image of the other?

Distribute the "Who Opened the Refrigerator?" worksheet and ask students to figure out which of the suspects, A through K, is the culprit. You may want to guide their application of a logical, empirical problem solving method. First, they should identify the basic pattern of the print found on the refrigerator. (It's a whorl.) Next, they should figure out which of the suspects has a whorl pattern. (A, C, D, and K have the whorl pattern and thus have become "prime suspects;" the others are no longer suspects.) Next, students should look more closely at the whorl pattern found on the refrigerator for distinguishing characteristics. They may note the long central line in the middle of the unknown's whorl. (A and D have a short central line which is almost a dot, so A and D are eliminated. C and K remain as "prime suspects" because they do have the long central line.) Finally, the students can see that the whorl of the refrigerator raider spirals in a clockwise direction. To see this, have students look at the center of the whorl and follow a ridge as it spirals outward. (C's whorl spirals counterclockwise, and K's whorl spirals clockwise. By a process of elimination, K has been identified as the refrigerator raider.)

If you have done binary classification activities from Information Manipulation or have done other binary classification activities (e.g., used a dichotomous key), you can point out that those classification skills were being used here. That is, a series of characteristics were observed and the fingerprints were divided into two groups, those with and those without the characteristic. Each new observed characteristic further subdivided the fingerprints until only the remaining print had all of the characteristics that matched the raider's print.

D

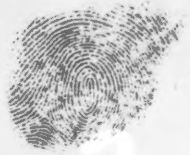
As a final activity, students' ten prints with their names on their own prints and their unnamed right index fingerprints could be put on a bulletin board or some comparable place. As students have time while others are doing other activities, they can match the unnamed with the named prints. To speed this process, you may want to subdivide the prints into groups of, say, five; otherwise, an unnecessarily lengthy matching process may detract from the central purpose of teaching classification skills.

Worksheet 2

Who Opened the Refrigerator?

Which fingerprint was made by the person whose print was found on the refrigerator?

Fingerprint found on the "off limits" refrigerator.



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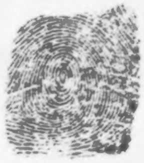

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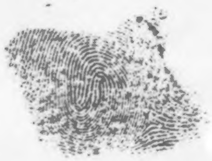

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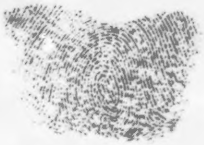

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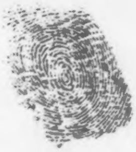

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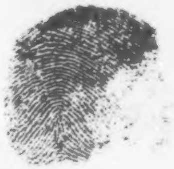

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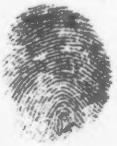

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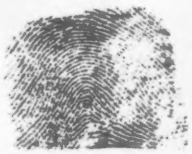

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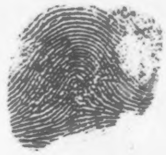

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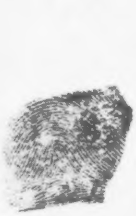

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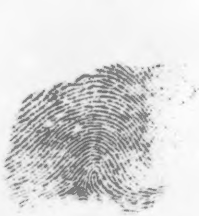

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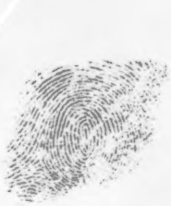
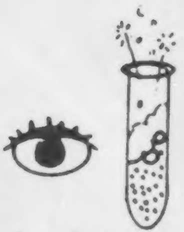


Activity II: Chemical Evidence



Materials:

- Five white powders: baking soda, cornstarch, flour, powdered sugar, and talcum powder (unscented, if possible).
- Paper towels.
- Newspaper.
- Tincture of iodine (diluted with water to the color of weak tea).
- Vinegar (may be diluted to make it serve more students).
- Water.
- Containers for liquids (baby food or similar jars).
- Medicine droppers or soda straws (cut in quarters).
- Candles.
- Alumninum foil.
- Clothespins (wooden pinch type).
- Hand lens.

Background Information:

Law enforcement personnel daily use chemistry and physics in solving crimes. Crime laboratories identify blood, poisons, bits of glass, hair, fiber, and so forth, found on the victim, at the scene of the crime, and elsewhere. The laboratory may be highly specialized with experts working in relatively narrow fields, or the worker may perform a variety of techniques.

The forensic laboratory takes physical evidence and compares it with other evidence (e.g., are glass fragments found on a victim's and a suspect's clothing from the same source?) and also may compare it with known information and materials on file. The lab worker depends on several tools including the microscope and a series of specialized electronic instruments.

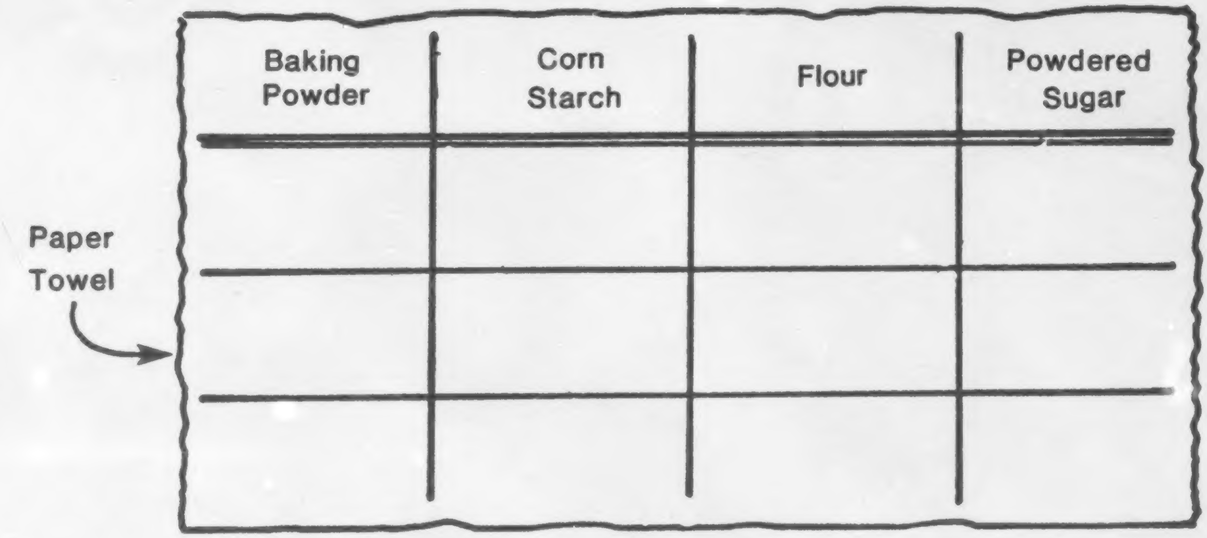
In this activity students make a file of information which they can subsequently use to identify unknowns (collected evidence). To record information for their files, the students will perform several tests on known powders. They will then be given three unknown white powders on which they will perform the same tests. By comparing results from tests of the unknown powders with the known powders, the students can draw conclusions about the unknown's identity. In chemistry labs, this identification of unknown substances is called qualitative analysis.

The point of this analysis activity is not that students learn how to identify four white powders. That's too narrow a goal. The point is to teach students a qualitative analysis procedure of making comparisons between knowns and unknowns.

Procedure:

This activity takes some time. Perhaps the activity could be divided by having students collect information about knowns prior to the resource person's visit and then identifying unknowns during the visit. Students can work individually or in small groups, depending on availability of materials. Students should be cautioned on the proper use of candles to prevent mishap.

Each individual or group should be given about one-eighth cup each of vinegar and iodine. They can spread newspaper to work on. Each group should draw a three-by-four grid on a paper towel and mark the four columns: baking soda, cornstarch, flour, and powdered sugar. Then they should put about a quarter teaspoon (precision is not required) of each powder in the three boxes in each column. For keeping track of their findings, on separate paper they should also make a four-by-four grid with each column labeled with the powders' names and each row labeled with the tests' names.



D

The students are now ready to perform four tests. First, they should look at each powder with a hand lens and describe the particles on their data sheet. Second, they should put a drop of vinegar on one sample of each powder. (Baking soda will fizz as the acid in vinegar reacts with the carbonate in baking soda to produce carbon dioxide. The other powders will show no distinctive effects of adding vinegar.) Third, they should put a drop of iodine on one sample of each powder. (Starch turns dark blue-black when iodine is added. The others show no distinctive effects from iodine.) Fourth, they should heat a sample of each powder. To perform this test, have them make a nut cup-sized alumninum foil bowl for each sample. The foil can be held in the pinch type, wooden clothespin over the flame. The candle can be held in place with a few drops of wax or a little clay. Show students how to waft a bit of gas to their nose with a cupped hand. (Sugar will caramelize fairly quickly when heated producing a distinctive burnt sugar odor. The starch will eventually produce a faint burnt sugar odor as the starch molecules break down to sugar and then caramelize, but this is a much slower and less distinct process than exhibited by sugar.)

After all the reactions have been performed and the results discussed, tell students they will be given samples of three unknowns. Tell them to use their file of information to identify the unknowns. They should be able either to identify the unknown by name or to determine that the unknown is not one of the known powders. The unknowns should be labeled only as A, B, and C. In container A, give students powdered sugar; in B, a mixture of baking soda and cornstarch; and in C, talcum powder.

After performing the tests, students should be able to identify A by name, B as a combination of two knowns, and C as being something new. After they have tested their unknowns tell them it is absolutely correct that they identify C as not one of the knowns. What is important is that they did the test and came to that quite valid conclusion.

The work of Cathy Thomas (see "Women and Forensic Science") can be mentioned here.

Activity III: More Unknowns

Materials:

- Aspirin tablets (some fresh and some as old as you can find).
- Steel wool (if it contains any soap, carefully pull the wool apart under running water until the soap is washed out).
- Old saucepan.
- Hot plate.
- Vinegar.
- Paper filter (such as used in some coffee brewers).
- Funnel.
- Jar.
- Hydrogen peroxide.
- Medicine dropper or straw cut in quarters.
- Rubbing alcohol.
- Diluted iodine (tincture of iodine diluted with water to color of weak tea.)
- Two spoons.

Background Information:

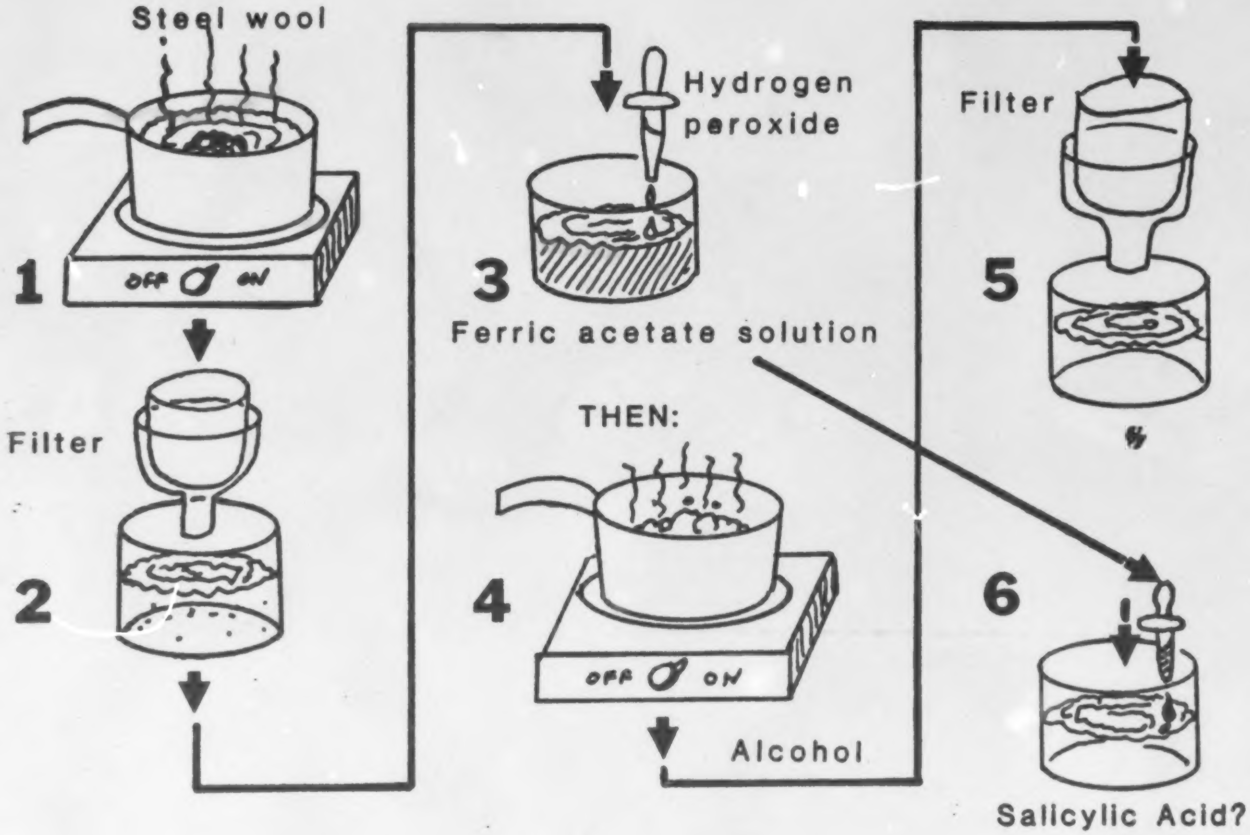
This activity is designed to determine whether starch and/or salicylic acid is present in an aspirin tablet. These tests are analogous to tests done by forensic scientists. They probably should be done as a demonstration.

Aspirin, acetylsalicylic acid, is an interesting chemical product of salicylic acid and acetic acid (that's the acid in vinegar). Salicin, a source of salicylic acid, is found in the bark of willow trees and has long been used to treat fevers, aches, and pains. Indians used willow bark to treat stiff joints, believing that because the willow was a flexible tree, its flexibility could be passed on to the person who chewed the bark.

Procedure:

To determine whether starch is present in aspirin, the same starch test used in Activity II is performed here. Crush an aspirin tablet between two spoons and drop some iodine on the powder. Iodine turns dark blue-black in the present of starch. (Starch is used in aspirin tablets.)

To test for salicylic acid, use a ferric acetate solution by following these directions. Put a piece of soapless steel wool (steel is almost all iron) into a saucepan and cover with vinegar. Bring the solution to boiling and simmer for five minutes. Pour the contents through a filter (folded and placed in a funnel) and collect the nearly colorless filtrate (i.e., the liquid that runs through the filter). To the filtrate add a few drops of hydrogen peroxide until the solution turns a bright reddish brown. Iron combines with acetic acid in the vinegar and peroxide to form a ferric acetate solution.


Steel wool
1
OFF ON
Filter
2
Hydrogen peroxide
3
Ferric acetate solution
THEN:
4
OFF ON
Alcohol
Filter
5
6
Salicylic Acid?

In a small saucepan, barely cover three or four crushed aspirin tablets with warm water. Boil away most but not all of the water. Pour ¼ cup rubbing alcohol into the pan and swish the contents. Pour this mixture through a clean filter. Add the previously-made ferric acetate solution dropwise to the filtrate. Iron turns blue in the presence of salicylic acid.

81

This test should be done with both fresh and old aspirin. Fresh aspirin should not contain salicylic acid. However, as aspirin ages, the acetylsalicylic acid decomposes into acetic acid and salicylic acid.

The work of Cathy Thomas (see "Women and Forensic Science") or the Nobel Prize winning work of Rosalind Yalow (see "Women and Body Detectives" in Body Detectives) can be related here. Note that Yalow's work is quantitative, while this test is only qualitative.

Career Information

People aspiring to a career in the new and growing field of forensic science should complete an undergraduate physical science program that includes analytical chemistry, instrumentation, biology, microscopy, and statistics. They may specialize in criminology at the undergraduate or graduate level with courses in (1) identification of explosives, drugs, and so forth, (2) investigation of specific types of crime such as arson or homicides, (3) specific techniques such as photography and collection of physical evidence, and (4) procedures such as record keeping and courtroom testimony. In considering this career, students should think about not only the opportunity to apply an interest in science but also the prospects for occasional unpleasant situations such as collecting evidence in a homicide or being threatened by a suspect or convicted felon who is unhappy with the person viewed as having caused the suspicion or conviction.

Related Activities:

Evidence. Part of the "Search for Solutions" series available free from Playback Associates, 708 Third Avenue, New York, New York 10017.

COMETS Profiles:

Geneva Hammaker: Chemist.
She applies her scientific skills to solve a varity of problems in a private consulting firm.

For More Career Information Write:

American Chemical Society, Department of Educational Activities, 1155 Sixteenth St., N.W., Washington, D.C. 20036. (Ask for Careers Nontraditional by Pamela Ayre and Patricia Lemaire, from which the information about Cathy Thomas for this module was gathered).

Career Oriented Modules to COMETS Explore Topics in Science

TOPICS

- Water
- Weather
- Aquatic Biology

Fluid Follies

RESOURCE PEOPLE

- Hydrologist
- Meteorologist
- Biologist

THIS MODULE

Activity I

"Physical Water" emphasizes surface tension, cohesion, and convection currents in water, so this activity is quite appropriate for hydrologists, but by analogy, it can also be used by meteorologists. (Note that this activity was especially included for meteorologists to be able to demonstrate convection currents; but water, instead of air, was used because convection is more easily demonstrated and manipulated in water.) Both brief and extended activities are included. All equipment is homemade and generally easily gathered. Since lots of water is used, this and all activities in this module can be messy. Measurement of surface tension by Agnes Pockels can be related to these activities.

Activity II

"Hay Infusion" allows students to observe aquatic microorganisms. With assistance from a biologist, students may name some creatures. Extension activities deal with eutrophication (one form of water pollution) and ecology. Students study the process of experimentation. Microscope(s) or at least hand lenses are needed. The activity could be condensed into a brief look at the microorganisms, but a longer time is preferable. Ruth Patrick's study of streams can be mentioned here.

Activity III

In "Stream Flow" students investigate the use of physical and mathematical models to learn about full-scale phenomena, in this case, streams. Equipment can be handmade, but some fairly extensive preparation is needed. At least 30-45 minutes should be allowed for activities. Challenge Cards are included. Hydrologists or geologists are particularly good resource people. Ruth Patrick's work can be mentioned.

University of Kansas School of Education Department of Curriculum and Instruction

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RELATED MODULES

Fluid Follies is intended primarily to be used by hydrologists, oceanographers, meteorologists, and aquatic biologists; but these resource people might also use the following modules in their classroom visits.

Soil

Students investigate water flow in various soils (appropriate for a soil scientist or hydrologist) and/or living organisms in the soil (appropriate for a biologist).

Through the Air

The various properties of air studied in Through the Air provide additional activities for the meteorologist.

Outdoor People

The aquatic biologist or other biologist could relate to these environmental investigations.

WHERE TO FIND RESOURCE PEOPLE

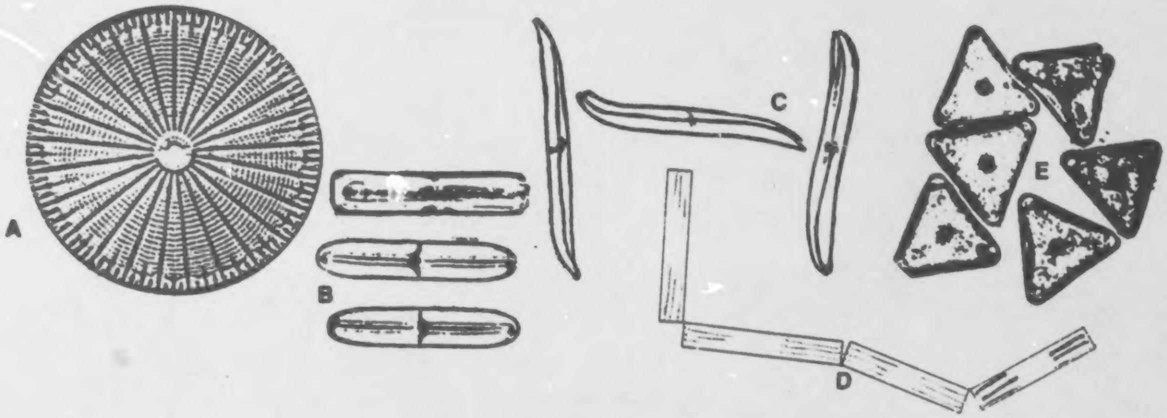
The federal National Oceanic and Atmospheric Administration, NOAA, employs many meteorologists and oceanographers. Environmental Protection Agency, Soil Conservation, Fish and Game, Geological Survey, and the various armed services are examples of national, state and local governmental agencies which employ people with specialties in careers related to these modules. Look under "Government" in the phone book yellow pages. Contact your county agriculture extension agent, soil conservancy, or water utility for referrals. Radio and television are employing more trained meteorologists. Power companies, oil companies, and other industries employ water specialists, since good stewardship of water is of increasing importance. Many universities and museums employ specialists in these areas and can also be a source of students majoring in these careers. Most amateur or professional pilots could lead the convection activities in "Physical Water" and relate this demonstration of convection to their understanding of the effect of atmospheric conditions on their flying.

Women and Water

Ubiquitous water - so mundane it fades out of consciousness. At least "dihydrogen oxide," H_2O, used to be ignored. But no more. Industries such as metal refineries, paper producers, electricity generators, and agriculture consume vast volumes of the precious liquid; and we now wonder and worry about maintaining an adequate supply of potable water. Private individuals and groups, governmental agencies, and business and industry busy themselves with numerous investigations and planning efforts. One prominent scientist working in the midst of the fray is Dr. Ruth Patrick, whose lifelong study of streams earned her the John and Alice Tyler Ecology Award, carrying with it $150,000, the world's richest scientific achievement prize.

As a limnologist, one who studies aquatic life in streams, lakes, and similar bodies of water, Dr. Patrick has become a world renowned expert on diatoms, a kind of microscopic algae, and their significance in gauging the health of a stream. After wading into the stream with dip net in hand to gather samples, she and other limnologists can quickly apply her diatom classification system to ascertain the degree and type of pollution of the stream.

Diatoms



A. Arachnoidiscus: B. Pinnularia : C. Pleurosigma: D. Pinnate: E. Triceratium.

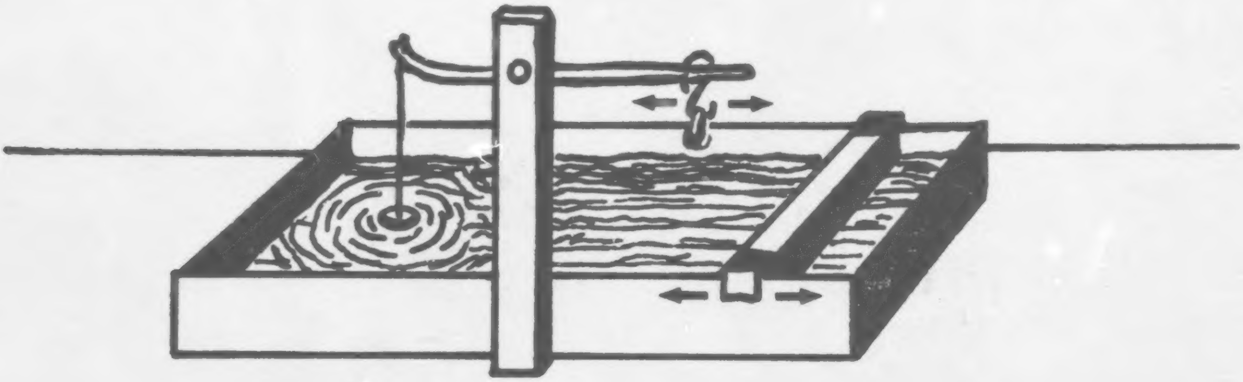
Diatoms are interesting unicellular creatures. Numbering in the thousands of species, they make up a majority of algae and have been present on the earth throughout most of its geological history. Diatomaceous deposits are mined to use as thermal insulation, paint fillers, and mildly abrasive polishing agents for lenses and mirrors. Living diatoms form the base of the stream's energy/food pyramid, capturing the sun's energy and in turn providing vital nutrients for insects, mollusks, fish, and other inhabitants at the higher levels of the pyramid.

The work of Dr. Patrick as a limnologist can be related to Activity II, "Hay Infusion," and the ensuing extension activities. Although students won't be concentrating on diatoms, they will be studying aquatic microorganisms and some of their effects.

Ruth Patrick usually studies existing streams, but one of her numerous, interesting projects was based on a stream she had constructed from scratch by heavy earth movers. Her purpose was to simulate conditions found in real streams and to learn how pollution problems developed over time in these various settings. In this regard, Dr. Patrick was applying the scientific technique of modeling, i.e., building and studying a replica of the real thing, but on a small, more easily manipulated level. Relate Dr. Patrick's use of the modeling technique to Activity III, "Stream Flow." The Search for Solutions movie, Modeling, demonstrates several applications of this technique (see bibliography).

While the university-trained Dr. Ruth Patrick studied water on a grand scale, the self-taught Agnes Pockels studied water on an almost microscopic level. She was interested in the various properties of surface tension. "Big deal," you might think while stiffling a yawn. Well, yes, big deal. Surface tension is significant in our every day lives . . . we add soap to water to break down surface tension to clean dishes and clothes. We spray water proofing on textiles to resist water's wetting the fabric, and we add materials to water so chemicals will dissolve and perform better in the water. As our nation has become more dependent on imported oil and increased our offshore drilling, petroleum spills have multiplied. Cleaning up those disasters depends heavily on understanding the surface chemistry of petrochemicals. To dramatize for students the importance of surface chemistry's applications to water, recall pictures of waterfowl doused in oil and in need of cleaning and oil slicks engulfing beaches.

On a more exotic level, biochemists study how water interacts with hormones, vitamins, and enzymes in order to gain a better understanding of how these materials work in our bodies. This study is based on the growing recognition that materials behave differently at their surfaces (where they contact other materials) than within themselves. Note, for instance, that you can very carefully float a needle on a bowl of water, but once the "skin" of the water is broken, the needle sinks.



Pockels built an ingenious gadget to measure surface tension. She suspended a button from one end of a balance (see illustration) and floated it on the surface of a liquid. She moved a weight out toward the end of the balance until the button "broke loose" from the liquid. The balance works like a seesaw. The further out toward the end a person sits on the seesaw, the more downward force the person exerts. Likewise, the further out Pockels had to move the weight on her balance, the more downward force it was exerting and therefore the more surface tension there was. Conversely, if there was only a little surface tension in the liquid being measured, the less far out the weight had to be moved before the button would break loose from the liquid.

In 1932 Irving Langmuir was awarded the Nobel Prize for his work in surface chemistry. Much of his research dealing with oil films floating on water was an extension of Pockels' work, which while crude, was truly innovative and won her recognition, including the 1931 Laura-Leonard Prize from the German journal Kolloid-Zeitschrift (Colloid Journal).

Students study surface tension in the first activity when they spread pepper on the surface of water and then touch the water with a soapy finger. This can be nicely related to Pockels' work. (For a more extended treatment of Pockels' work, see "Agnes Pockels - Indeed a Lady" by Eleanor S. Elder, in the January 1974 issue of Chemistry (vol. 47, no. 1, pages 10-12.)

Activity I: Physical Water

Materials:

- Bowl of water.
- Pepper, talc, flour, or other powder.
- Soap.

Procedure:

This activity can be done as a demonstration with students gathered around; or with more sets of equipment, it can be done by individuals or student pairs. The latter option is preferable, so that everyone "gets a chance;" but materials should be gathered up before the resource person launches into a discussion of the phenonenon.

Ask students to sprinkle pepper or other powder over the surface of a bowl of water. They should touch their finger first to soap and then to the center of the water surface. As soon as the soap touches the water surface, the pepper dramatically shoots to the perimeter of the bowl.

There's a little pushing and a lot of pulling going on here. As the soap spreads out, it pushes the pepper ahead. Also, when the soap touches the water surface, it destroys the cohesiveness of the water at that point (see Extension Activity 1 for a demonstration of water's cohesiveness). The water away from the point where the soap touches, however, is exerting a cohesive (pulling) force. Thus, the water in the middle (where the soap has been introduced) is no longer pulling, but the water at the outside (where the soap hasn't arrived yet) is still pulling. It's like a tug of war where one side lets go; the other side suddenly falls backward because there's nothing pulling against it anymore. Similarly, the outside water pulls back toward the outer rim of the bowl carrying the pepper with it.

The contributions of Agnes Pockels to measuring and studying surface tension of liquids should be mentioned in connection with this activity. Describe her technique for measuring just how strong the surface tension was.

Extension Activity 1: Penny Water

Materials:

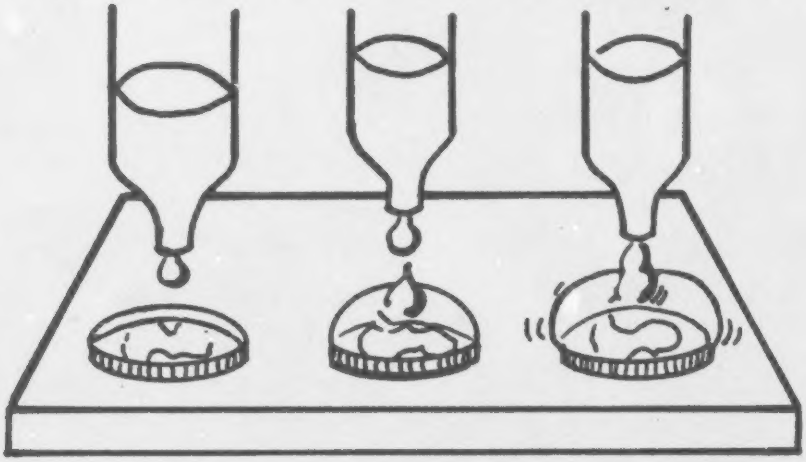
- Penny or other coin.
- Medicine dropper or straw.

- Water.
- Soap, preferably liquid.

Procedure:

Ask students how many drops of water they can get on a penny. Explain that, of course, they will have one big water drop on the penny; but the question is, "How many drops of water can be added to make this big drop before it spills off the penny?" Guesses usually range from a half dozen to a dozen, but a few will be "far out."

After the guessing, form as many groups as there is equipment to use and instruct students to add water carefully; they're not bombardiers. To the amazement of most, they usually can get 30-50 drops of water to stay on each penny; and they should be able to note how the water piles up before spilling.



Next, have students mix a few drops of soap in their water and repeat the procedure. They will find that many fewer drops of water are able to stick on the penny. (Ask students to carefully clean their equipment. If any soap remains in the containers or medicine droppers, the next group will have soapy water right away and not be able to see tap water pile up on the penny.)

This activity nicely demonstrates water's cohesiveness, its ability to stick to itself. When soap molecules are interspersed among the water molecules, the water's cohesiveness is dramatically reduced. That's good from a cleaning point of view. Soap is interesting because one end of the soap molecule "sticks" to water and the other end "sticks" to grease and dirt. Thus, when the soapy water is wiped or drained off the object to be cleaned, the dirt goes with it.

Extension Activity 2: Convection

Materials:

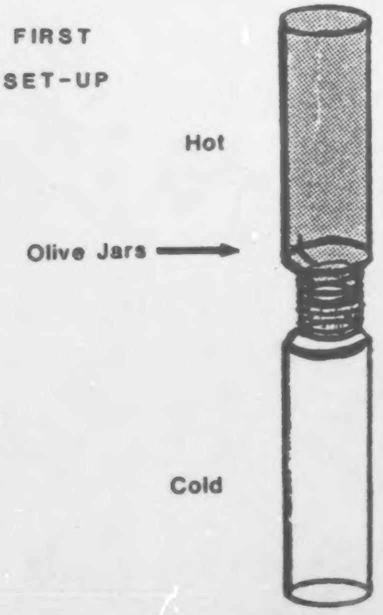
- Two identical glass jars. Olive jars work nicely. Four jars work better, since the two parts of the procedure can then be done simultaneously.
- Water, both hot and cold.
- Food coloring.
- Index cards.
- Newspaper and perhaps tray to catch spilled water.

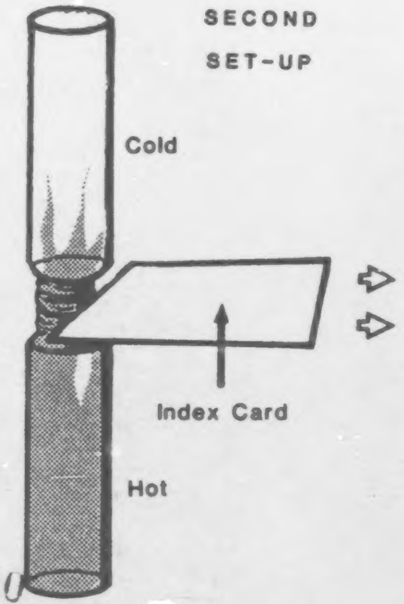
Procedure:

This activity works nicely as a demonstration, but students can continue making observations following the research person's visit.

Fill two jars completely to the brim, one with hot water and one with cold water. Add food coloring to the hot water. Cover this jar with an index card and quickly but gingerly invert the jar while holding the card in place. Work over newspaper and/or a tray to catch spills. (You could let go of the index card at this point, but that's another mind capture and another concept.) Carefully place the inverted jar over the other jar and remove the index card. The jars can be left undisturbed and the two waters will not mix for awhile.

The same two jars or preferably two new jars can be used in the same manner; but this time invert the cold water. As can be seen by the use of food coloring, the two liquids quickly mix when the card is removed.


FIRST SET-UP


SECOND SET-UP

What happens here is due to the differing densities of warm and cold water. Warm water is lighter (less dense) than cold water. When the warm water is on top, it stays there because it floats on the cold water. However, when the cold water is on the top, it sinks because it is heavier.

The movement of the water is an example of convection, which is the transfer of heat energy via the movement of any material. Wind is a convection current of air. Warm air rising from a register is another convection current. Extension Activity 3 shows another example of convection in water.

This brief demonstration of convection can be related by the hydrologist or meteorologist to fluid movements (liquid or air), an understanding of which is important in their respective careers. Following the resource person's visit, students may want to work with various combinations of water temperatures in the jars - cold/cold, warm/warm, warm top/cold bottom, etc.

Extension Activity 3: Convection Experiments

Materials:

- Container, such as an aquarium or pyrex cake pan.
- Support stand (see diagram on page 10).
- Candle.
- Ice.
- Food coloring.
- Newspaper.

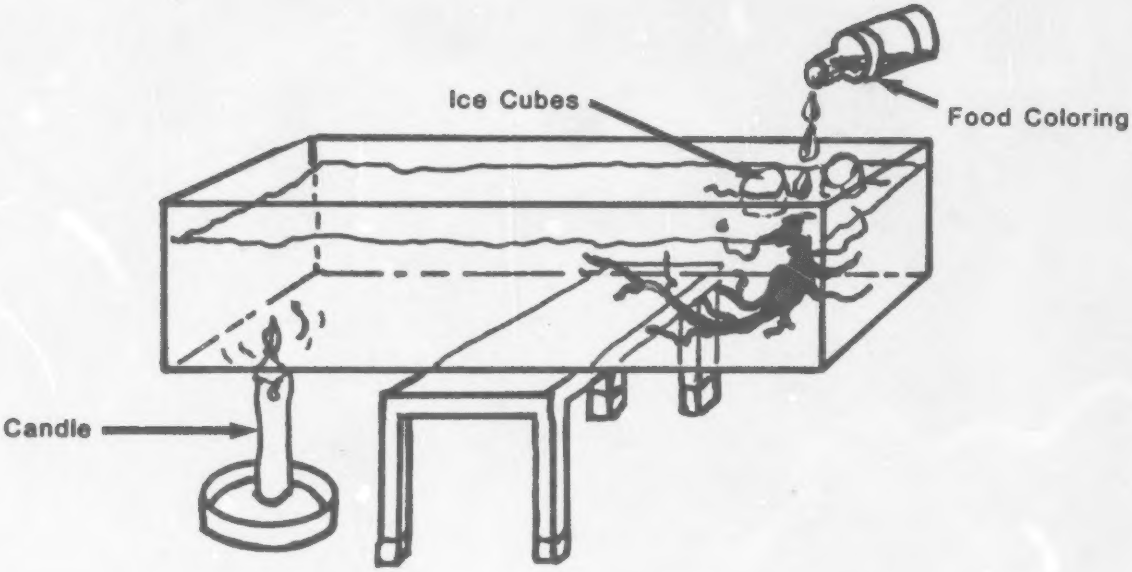
Procedure:

This activity could be done following Extension Activity 2 or independently. It can be a rather brief demonstration or an extended set of experiments.

Set up the materials as shown in the diagram on page 10. As the ice melts, the movement of this cold (denser) water can be traced by watching the food coloring as it sinks down. As the colored water spreads along the bottom (an example of convection), it is warmed in the vicinity of the candle, becomes less dense, and thus starts to rise.

As time is available, your students can experiment with variations on this procedure. Challenge them to reverse the movement of the water. What happens if the ice and candle are placed on the same ends of the container?" What happens if candles are placed on both ends of the container and the ice is put in the middle?

E



After the activity ask questions so that students can apply this information about convection currents to air. "Suppose you were sitting just inside a cave on a hot, sunny day. Would there be a breeze? If there is a breeze, which way would it blow?" (There would be a breeze out of the cave as the warmer, outside air rises and is replaced by the cooler air inside.)

Start the next question with this statement, "Dirt warms and cools more rapidly than water when the sun shines and then sets during the day. Air above the dirt or the water is warmed by the dirt or the water rather than directly by the sun." Here's the question. "Suppose you had a home on the beach. When the sun comes up, would you expect a breeze? If yes, which way would the wind blow." (Since the sun heats the dirt faster than the water, the air over the dirt is warmed more rapidly. As this air rises, cooler air from over the water moves (blows) toward shore to replace the rising warm air. The reverse happens in the evening. Sailing ships used to leave port in the evening, if possible, to take advantage of the offshore breeze. They also had to be concerned about the tides, so they didn't always leave in the evening.)

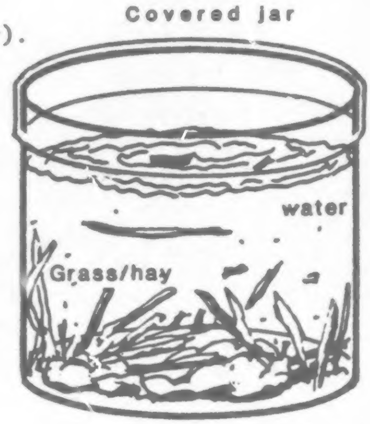
Activity II: Hay Infusion

Introduction:

Activity I was concerned with some of water's physical properties. By analogy, these properties could be applied to air. Activity II, on the other hand, deals with biological phenomena occurring in water. This activity can be enhanced by relating it to Ruth Patrick's work in measuring and understanding stream life.

Materials:

- Pond or other natural water (not purified water).
- Hay or dried grass.
- Three glass jars (e.g., mayonnaise jars).
- Pan.
- Hot plate or stove.
- Microscope or hand lens.
- Microscope slide.
- Medicine dropper.

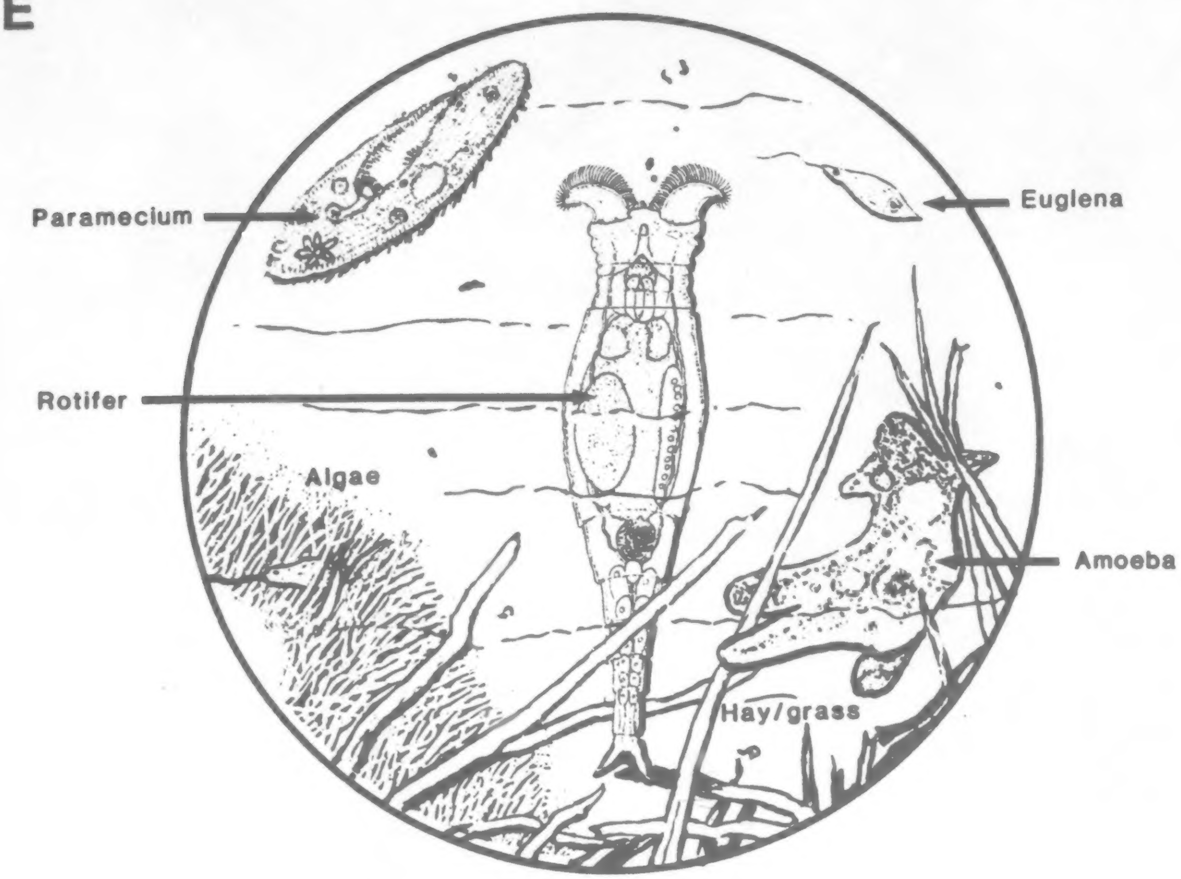


Making Hay Infusion:

Add a small handful of hay or dried grass to about a quart of water in a saucepan or similar container and boil it for about ten minutes. Allow the water to cool overnight and carefully pour about one cup of this liquid into each of three quart jars. (If equipment is available, the liquid can be filtered to keep out debris; but careful pouring negates the necessity of filtering.) This liquid provides a good diet for numerous microorganisms. To each jar add about two cups of fresh pond water or water from another untreated source. This fresh pond water contains the critters which will live and multiply (to a point) in the hay infusion.

Procedure:

Place a drop or two of the prepared hay infusion on a glass microscope slide and observe with a hand lens or under a microscope. The better the optical instrument and the students' technique, the more microorganisms will be seen; but in any event, your students should become aware of the abundant, aquatic microscopic life, some of which are shown in the illustration on page 12.



Hay Infusion

A biologist or hydrologist resource person could begin a classroom visit by having students observe aquatic microorganisms. Alternatively, students could be involved from the beginning, preparing and observing the hay infusion prior to the resource person's visit. Regardless of when students do their observing, resource people should point out some of the organisms present in the infusion and relate how they use information about what is in the water in their work.

Extension Activity 1: Hay Infusion Experiments

Material:

- Same as above.

Procedure:

The preceding activity makes students aware of the presence of microorganisms in water; this activity is designed to extend that awareness to an understanding of populations and their succession within a particular environment. This activity takes several days or weeks, so it should follow the resource person's visit; or the resource person could comment on the activity after its completion. Alternatively, a resource person might be willing to work as an advisor to a small group of students or individuals particularly interested in this project. In this case the resource person would be working much like a scout merit badge advisor.

Have students prepare the hay infusion and then count various types of organisms they observe in a drop of the infusion. The resource person may assist in identification of microorganisms. Whether by name and/or by a sketch, students should record the number of each type observed and the date of their observation. (These numbers will of necessity be estimations.) Students should repeat this observing and data recording every four days for approximately four to six weeks. At the end of that time students should prepare a bar or line graph with time on the horizontal axis and number of each type of organism on the vertical axis. Their graphed data should reveal the shifting populations; one organism will dominate and then subside as another organism dominates, and so forth. This ecological succession corresponds to what happens in real bodies of water or in other settings such as a field, forest, or prairie.

An alternative to this activity would be to prepare hay infusions with organisms from varying water sources, e.g., pond water, water trapped in a rotting tree, water standing in a field, babbling brook, and so forth. In this case, students would learn firsthand about habitat and how various organisms live better in these differing settings.

Extension Activity 2: Eutrophication

Materials:

- Methylene blue (available at aquarium shops).
- Two glass quart jars (e.g., mayonnaise jars).
- Pond water or tap water which should sit out overnight.
- Garbage (e.g., materials left after preparing a salad).
- Two tablespoons of soil.
- Cloth, size of handkerchief.
- String.

Procedure:

Ask each student or student group to bring these materials to school. (One small jar of methylene blue is sufficient for an entire classroom.) Mix a cup of garbage and two tablespoons of soil together in a handkerchief. Tie tightly. Fill two jars with water to near capacity; and stir in a few drops methylene blue until the water is a pale blue. (The same number of drops of methylene blue should be added to each jar.) Put the wrapped garbage and soil in one jar and place both jars near a window. Observe for a few days.

The methylene blue is blue when oxygen is present in the water, but becomes colorless when oxygen is removed. The garbage in the one jar will serve as a good food source for bacteria in the soil. This bacteria population will skyrocket and use up the available oxygen, as indicated by the water in that jar becoming colorless. (The control jar will remain blue.)

What happens in the jar happens on a larger scale when nutrients increase in a water source, as happens when seemingly innocuous materials such as high phosphate soap, fertilizer, or seepage from a garbage dump find their way into the water in increasingly larger amounts. This process of nutritionally enriching the water is called eutrophication. This "yummy" water is great for microbes which multiply in wild profusion. In a sense those critters never had it so good; but unfortunately they use up the oxygen in the water faster than it can be replenished; and they literally suffocate themselves (there's not enough oxygen to support their metabolism). The microorganisms then die, having committed suicide. So what? Well, eutrophication has several detrimental effects. One, the removal of the oxygen also means fish and other higher organisms do not have the oxygen they need. Two, the microorganisms which form the base of the energy/food pyramid are not available for the higher organisms. Three, the decay of the microorganisms produces poisonous products unhealthy for the higher organisms. In short, the pond dies.

The work of Ruth Patrick can be introduced in connection with this activity.

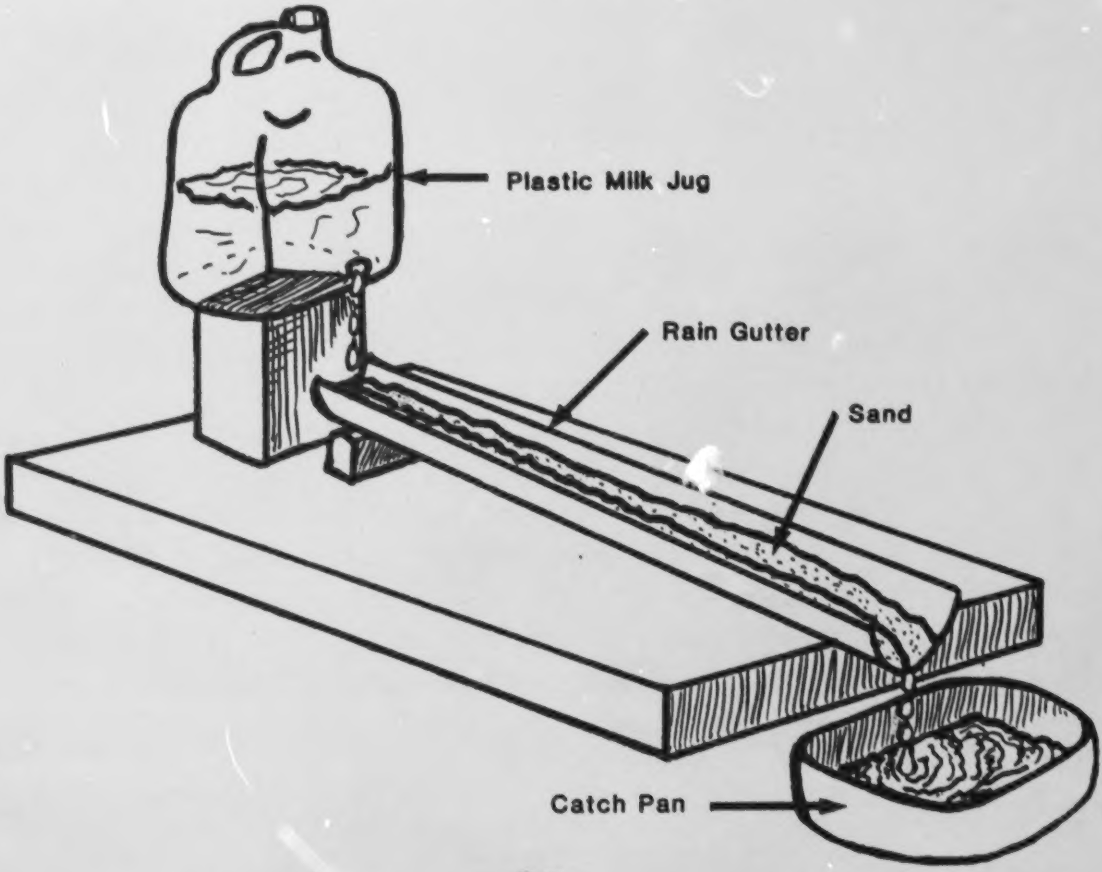
Activity III: Stream Flow

Materials:

- Stream table (see directions).
- Water.
- Newspaper.

Directions for Making Stream Table:

A stream table can be made by lining a long narrow box (about 4' x 2' x 4") with heavy plastic such as a trash bag. (This may be a good project for a woodworking or industrial arts class.) Fill the stream table with sand, which is clean, easier to use, and thus preferable to soil; or soil can be used. Prop up one end of the stream table near a water source. Water could come directly through a hose from the spigot or from a watering can made of a discarded plastic bottle. A catch basin is needed at the end of the table. The diagram shows a stream table made from a vinyl gutter and plastic bottle. Stream tables are also available from commercial suppliers.



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Procedure:

The stream table is an excellent way to test on a small scale variables that affect water flow. Relate how Dr. Ruth Patrick made a large scale model of a stream to study factors affecting the history of a stream (see "Women and Water"). This activity takes a variable length of time; but in no case would it last less then 30-45 minutes and in many cases it would extend over several days. Ideally students should work in small groups with stream tables; but with limited equipment the stream table could be set up as a learning center. Thus, the resource person probably should be asked to comment on rather than lead the activity.

Discuss with students the operation of the stream table and its purpose as a small scale model of a full scale stream. (You might want to show the movie, Modeling, referenced in the bibliography, to explicate further use of models by scientists.) Make these points. The sand should be wetted first. A channel can be made and varied in shape by hand. Obstacles such as pebbles can be placed in the stream. The slope can be adjusted by propping up one end; but the slope shouldn't become too steep because the sand may slide out. Water flow can be varied by changing the number of holes in the bottle, with the use of masking tape over holes if a plastic bottle is used, or with the faucet. Too large a water flow will wash out the sand.

After getting students oriented to the stream table, discuss with them variables which may affect stream flow and allow them to test some of these variables. They might vary slope, water volume, shape of the stream, and/or presence of obstacles. If they haven't previously discussed the necessity of manipulating only one variable at a time, this would be a good place to discuss experimental methods.

After students have finished these rough observations, you might challenge them to quantify some of their qualitative observations. For instance, they probably observed that the slope of the stream affected how fast the stream flowed; but how can that relationship be pinned down more precisely? Ask students how they would measure slope. They should be able to measure the slope with a protractor (angle of table) or a ruler (height of propped up end). Measuring rate of flow is more challenging and should be discussed fully by the students. One suggestion is to add a drop of food coloring to the water and time how long it takes the drop to travel a measured distance. Another way to measure flow is to time how long it takes a certain volume (e.g., a quart) of water to flow out of the bottom of the stream and be collected. (What the students are doing is operationally defining the variable, rate of flow, which is precisely one task of a hydrologist.) After alternative methods of measuring the variables have been suggested, allow students to apply their operational definitions and then graph their results. Discuss their results. For example, is there a direct arithmetic relationship between slope and rate (indicated by a more-or-less straight line on the graph) or is there a more complicated relationship (indicated by some sort of curved line)?

Extension Activity 1: Challenge Cards

Materials:

- Challenge Cards (optional).

Procedure:

After taking students together through the preceding activities, you can challenge students to do some individual investigations. (You may want to reproduce and hand out COMETS Challenge Cards.) Challenge students to select one of these problems to study:

- Measure erosion in at least three different ways.
- Slow down or speed up erosion in at least two ways.
- Figure out whether water flows faster on the inside or outside of a curve. What effect does this variable flow rate have on changing the course of the stream? How can this effect be prevented or at least slowed?
- What happens to stream flow (both rate and volume) when you alter the stream's shape?

Extension Activity 2: Mathematical Models

Materials:

- Brains!

Procedure:

Following the construction and testing of the stream table, you can go further by pointing out to students that they have been working with a physical model of a stream. However, it is not always convenient, and it becomes costly to build a physical model. Imagine the cost involved in building a model of the Japanese waters shown in the Search for Solutions Modeling movie. Models can also be made as mathematical models, which may not be nearly so much fun, but they can be very useful. They're less expensive and,

E

if used properly, may be more accurate than physical models in their predictions about hydrologic or other problems.

Mathematical models are usually made or derived from physical models. You can see in a general way how this is done by changing a single variable, such as rate of water flow, and holding others, such a slope, constant. For example, what happens to the size of the channel in the stream table when a large amount of water is released? If enough water passes through, the sand will move, or erode, and the "channel" will get wider. If you place obstructions, such as two boards or bricks (or anything that the water cannot move) on either side of the "channel" and constrict the flow, the velocity should increase within the constricted part of the channel. You can check out this situation with your physical model, or you can apply a mathematical model.

A simple mathematical model that relates the rate of flow and channel size is the formula, $Q = AV$, which summarizes what was previously observed in physical models. This formula says that Q, the quantity or volume of water that passes through a stream's cross-section in a given time period (also called stream flow or discharge), is equal to A, the area of the water-filled stream channel, times V, the velocity or speed of the flowing water. Knowing the mathematical model, one can make predictions without resorting to making and testing the physical model. What happens to discharge if the area of the water-filled channel increases with a constant velocity? (The quantity of discharge, Q, increases.) Vice versa? (Q decreases.)

Using this mathematical model, how could you find out how much water is flowing in a real stream? First, measure V, velocity of water, by putting a small boat in the water and measuring how long it takes to travel a certain distance, say 100 feet. Then velocity = distance/time. To measure cross-sectional area, A, assume the stream is roughly a triangle. The area of a triangle = 1/2 bh. In this case b, base, is equal to the distance across the stream; and h, height, is the depth of the channel at its deepest point.

Say the boat travels 100 feet in five minutes. Then V = 100'/5 minutes or 20 feet/minute. Assume the distance across is six feet and it has a maximum depth of two feet. Then its cross sectional area, A, is 1/2 (6)(2) or 6 square feet. Now we can calculate Q, quantity of water passing a given point, with the formula, $Q = AV$. We've calculated A to be 6 square feet and V to be 20 feet per minute; so Q = (6 sq. ft.)(20 ft/minute) or Q = 120 cubic feet/minute. That's the volume of water passing a given point in the stream each minute.

Hydrologists make frequent use of this kind of mathematical model. Similarly, meteorologists use mathematic models to make weather forecasts. Both of these professions heavily use computers to apply mathematical models. Ask your resource person to relate their use of models and computers.

Career Information

Meteorologists, oceanographers, and hydrologists all need at least undergraduate training, but graduate training is preferred. These specialists apply science concepts to solve applied or basic research problems. Most are employed by colleges or governmental agencies, including the armed forces, but many are also employed in the private sector.

The majority of meteorologists work in some aspect of weather predicting. The National Oceanic and Atmospheric Administration (NOAA) is the largest employer in this field, employing 1800 meteorologists. Three thousand six hundred oceanographers, sometimes called marine scientists, work with biological or physical problems in the oceans. Many hydrologists, as specialists in one area of geology, work for the federal or state geological surveys. (See Soil for career information about geologists. Outdoor People includes career information about biologists, including limnologists.)

A very large number of people, 600,000, are employed in various engineering and science technician careers, including, for example, meteorological technician, agricultural technician, electronics technician, and aeronautical technician. Each of these technicians must complete high school, followed by vocational or technical school and/or on-the-job training. Many technicians receive their training in the armed services. While the types of technical careers are quite numerous, within each job there is generally more routine than found in careers requiring collegiate training. Technicians' jobs are usually "practical" rather than theoretical, although some have a measure of independence in solving specific problems. Engineering and science technicians need a math and science aptitude, must enjoy technical work often involving detailed work requiring great precision, and should be able to work under supervision with a team of people. Both public and private employers require large numbers of technicians with math and science ability. Adolescents who may not be considering college, but who have some science interests, should be encouraged to remain in math and science courses and consider technical careers.

Related Activities and Resources:

Crum, Lawrence E. Classroom Activities and Experiments for the Life Sciences. West Nyack, New York: Parker Publishing Co.

Garigliano, Leonard J. and Knape, Beth Jo. Environmental Education in the Elementary School. Washington D.C.: National Science Teachers Association, 1742 Conneticut Ave., N.W., 20009. 1977. This module's eutrophication activity is based on "A Simple Classroom Experiment on Eutrophication" by Vivian and Albert Schatz (Science and Children, 11(7), April 1974, page 7) reprinted in this book (page 57) along with many fine environmental activity articles.

Modeling. Part of the "Search for Solutions" film series available from Playback Associates, 708 Third Avenue, New York, New York 10017.

Pond Water, Stream Tables, and Water Flow. Published by McGraw-Hill Book Company, 1221 Avenue of the Americas, New York, New York 10020. Three teacher's guides and optional equipment suggest activities for studying pond life and physical action of water.

Career Information:

Millard, Reed, et.al. Careers in Earth Science (1975) and Careers in Environmental Protection (1974). New York: Julian Messner.

Women and Water:

Emberlin, Diane. Contributions of Women: Science. Minneapolis: Dillon Press. 1977. Biographical sketches of six women including Ruth Patrick (limnologist featured in "Women and Water"), Rachel Carson, environmentalist, and Eugenie Clark, icthyologist.

COMETS Profiles:

Gisela Dreschhoff: Physicist.
Among other areas of interest, this woman unlocks secrets of geological history frozen in Antarctica's ice.

Cynthia Dusel-Bacon: Geologist
This story of an amazing person grips the interest of all readers.

For Additional Career Information Write:

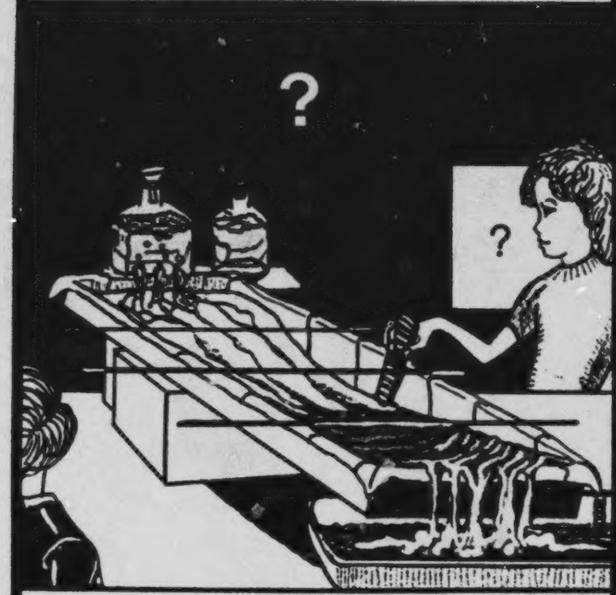
American Meterological Society, 45 Beacon St., Boston, Massachusetts 02108.

Engineering Council for Professional Development, 345 East 47th St., New York, New York 10017.

International Oceanographic Foundation, 3979 Rickenbacker Causeway, Miami, Florida 33149. (Send 50¢ for "Training and Careers in Marine Science.")

National Association of Trade and Technical Schools, 2021 K St., N.W., Washington D.C. 20006.

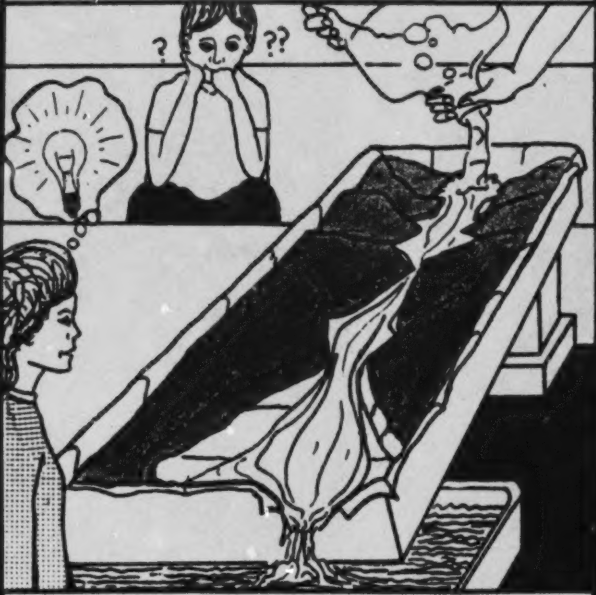
COMETS Challenge Cards



Fluid Follies

Find three ways to measure erosion.

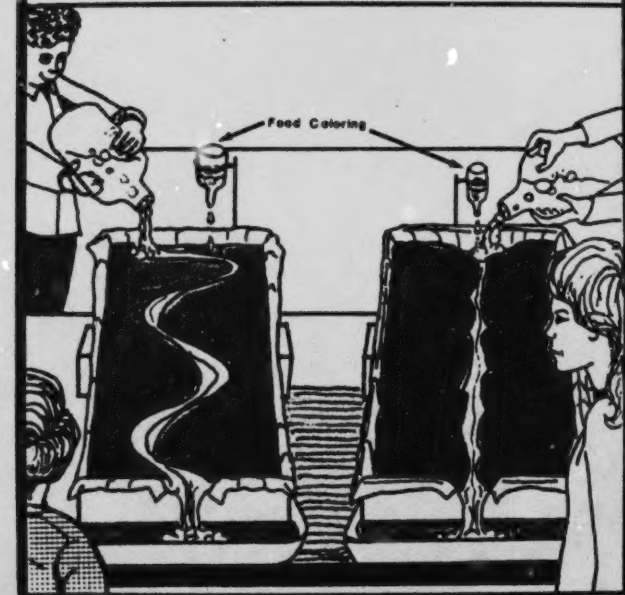
COMETS Challenge Cards



Fluid Follies

Can you figure out two ways to slow the erosion process?

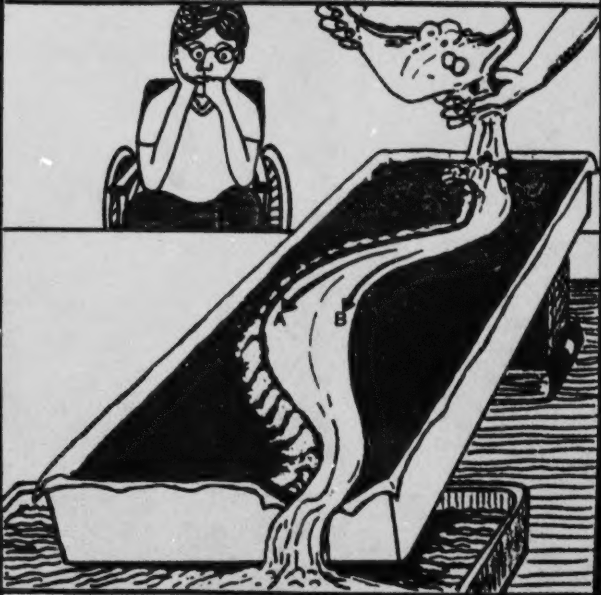
COMETS Challenge Cards



Fluid Follies

What happens to stream flow when you change the shape or direction of the stream?

COMETS Challenge Cards



Fluid Follies

How fast does water flow past point A? Past point B?

Career Oriented Modules to COMETS Explore Topics in Science

TOPICS

Reflection
Refraction
Eyes

Light and Sight

RESOURCE PEOPLE

Eye Specialist
Photographer
Astronomer

THIS MODULE

Activity I

"Mirror, Mirror" focuses on reflection with a brief mind-capturing activity that introduces the law of reflection. Students use two mirrors to produce a surprising image of themselves as others see them. All resource people who use light concepts could use this activity to initiate their visits.

Activity II

Emphasizing refraction, "Lenses" includes four activities, each of which could be done alone or in combination with others. The first two activities each use simple equipment and could be completed in 5-10 minutes. The latter two activities require some special equipment (e.g., prism) and are variable in time. Contributions of Barbara Askins to photography could be especially related to the extension activity, "Experimenting with Lenses;" and Annie Jump Cannon's contributions to astronomy can be mentioned when studying prisms or spectroscopes. All resource people who use lenses could conduct any of these activities.

Activity III

"Illusions" is a set of six activities which could be done separately or in any combination by eye specialists. The brain's interpretation of light stimuli is featured. Four challenge cards are included. Several activities require no equipment. All activities are brief, although each could be a starting point for additional study of perception.

University of Kansas School of Education Department of Curriculum and Instruction

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RELATED MODULES

Light and Sight is intended for people who use lenses and/or mirrors vocationally or avocationally and for eye specialists who apply concepts of sight.

Body Detectives

In "Spare Parts" students observe body parts, e.g., an eye, and instruments used to inspect those body parts. Eye specialists may want to weave together "Spare Parts" with "Illusions" from this module.

Through the Air

Professional and amateur astronomers work with students in observing the night-time sky. Discovery of pulsars by Jocelyn Bell can be related from that module to Light and Sight activities.

WHERE TO FIND RESOURCE PEOPLE

Eye specialists can be found in the yellow pages under Optometrist, Ophthalmologist (as a subcategory under physician), or Optical Goods. Photographers are listed there also or may be found through camera supply stores or photography clubs. Ask at the camera store about professional and amateur photographers and clubs. Astronomers, both amateur and professional, can be found in star gazing clubs, through colleges or universities, and through natural history museums or planetariums. A librarian may be able to refer you to people who borrow photography and astronomy materials. Scouts, 4-H, and other youth groups offer projects in these areas, so their leaders may be able to suggest resource people.

Spectroscopy, the focus of Extension Activity 3: Prism, page _____, is used routinely in many analyses. Chemists in industry, governmental agencies, criminology labs, and universities could use the Prism activity as a starting point to discuss their careers. See Product Improvement for further suggestions about where to find chemists.

Women and Light

Problem. Old photographs fade with age. How can they be rejuvenated?

Problem. Photos of the Orion nebula and other extraterrestrial worlds do not provide enough resolution to make out some significant details. How can these pictures be clarified so that that rich source of information can be harvested?

Dilemma: In order to detect some cancers at an early stage when treatment is most effective, crisp x-rays showing minute details are required. However, to obtain this detail the patient must be subjected to levels of radiation which themselves elevate the risk of producing cancer. Do you choose better detection at the risk of inadvertently producing new cancers; or do you choose to lower the radiation at the risk of overlooking some treatable cancers because of poor quality x-rays?

Barbara Askins' development of a process to enhance underexposed black and white photographs provides a solution for each of these difficulties; and for her work Barbara Askins was recognized as the 1978 Inventer of the Year by the Association for the Advancement of Invention and Innovation. Using Askins' technique, pictures that have been underexposed can be metamorphosed into normal prints that are up to ten times clearer than the originals.

Askins' invention involves immersing the original underexposed film in a low intensity radioactive solution of thiourea sulfur 35 (thi-o-urea). The thiourea sulfur 35 "sticks" to the original film producing an autoradiograph ("self-picture") which emits radiation in the form of beta particles. The autoradiograph can in turn be used to expose photographic film; and presto, an enhanced print of the weak original has been made.

Applications of this process are diverse, as has been indicated by the list of problems it has solved; but one particularly exciting application is in the area of cancer detection. Now, for example, women undergoing "routine" breast x-ray examination can be exposed to safer, lower radiation levels. Using Askins' technique, the resultant underexposed and somewhat fuzzy mammograms can be enhanced to a level of clarity previously available only in x-rays produced with lighter radiation levels. (Controversy, of course, continues over whether any level of radiation is completely safe. Nevertheless, there's general agreement that lower radiation doses are safer; and this lower level may be safe enough compared to the benefits of early detection.)

This photographic enhancement technique can be related to the "Lenses" activity which itself can be related to photography and other uses of light.

Another group of women involved with using light energy is composed of a host of astronomers who have contributed quite significantly to that field of study. Caroline Herschel (1750-1847), an English woman, discovered eight comets and several nebulae and star clusters. An American, Maria Mitchell (1818-1889), at age 29 sighted the first comet to be discovered with a telescope, and thereby won a special prize from the King of Denmark. Annie Jump Cannon (1863-1941) is the astronomer whom we feature here.

Cannon's major contribution made in her decades of work at Harvard University was as cataloger of over 300,000 stars and deviser of a system for catagorizing them. Stop for a moment and think about the thousands of stars you can see on a crisp, moonless night. Then contemplate how you might classify all those stars, all the other stars seen only through a telescope, all the stars visible at some other time of the year, plus a comparable number of stars visible only in the southern hemisphere. Annie Cannon took on that task and devised a system which was officially adopted and is still used by the International Astronomical Union and virtually all astronomers.

Cannon's classification system was based on spectrograms, a series of streaks of light produced when light is passed through a prism. By comparing light from a star with light from known materials, one can determine the composition of the star. Also, by comparing the position of these streaks of light in the spectrum with light from a stationary light source, the direction and speed of movement of the star relative to the earth can be determined. To illustrate this latter technique, remind students how the sound of a fast moving car changes as it approaches, passes, and then moves away from the listener . . . probably, perhaps to your chagrin, your students can demonstrate this series of changes in pitch so familiar to race car fans. Similarly, the movement of a light source, such as a star, changes the light's frequency, which we perceive as a change of color. Astronomers measure this color shift to figure out in what direction and at what rate the star is moving; whereas, the race car enthusiast judges the car's movement by the sound shift.

Annie Jump Cannon's contributions can be related to the "Lenses" activity as an application of spectroscopy and photography (virtually all of her cataloging was based on photographic plates) and to the "Illusions" activity. The connection to "Illusions" can be made by pointing out that the color shift caused by star movement is, in a sense, an illusion. The star produces a certain color of light; but we perceive a different color because of the star's movement relative to the observer.

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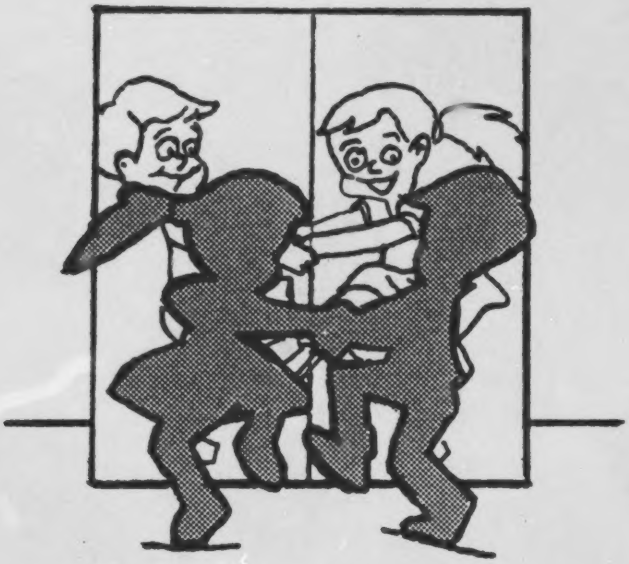
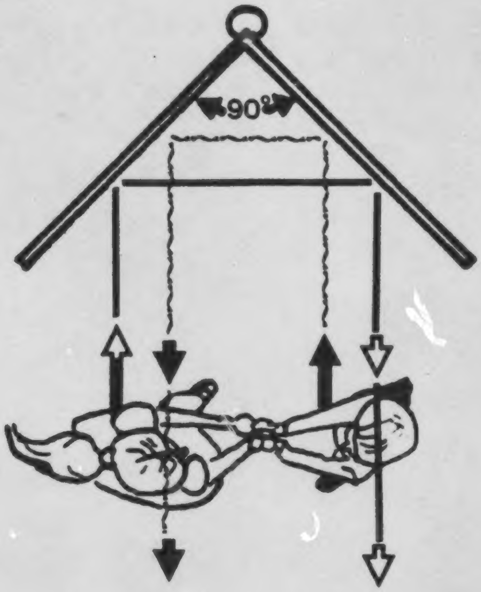
Activity I: Mirror, Mirror

Materials:

- Two square or rectangular pocket mirrors. (The more pairs of mirrors, the more rapidly and easily students can make the observations.)





Procedure:

Have students hold two mirrors side by side so that they can see their eyes; their nose's image should be on the juncture where the two mirrors meet. You or your resource person can stand behind students and look over their heads to help direct their positioning of the mirrors. When each student's image is in place, ask them to wink their right or left eyes. Not surprisingly the images will wink back in the expected manner. Wink the right eye; the image's left eye winks back. The image is the reverse of the real face.

Next instruct students to keep the mirrors touching and watch their image in the mirror, but rotate both mirrors with the outside edges of the mirrors coming toward their face. Continue rotating the mirrors until they're at a 90° angle. At that point the students' images, with their noses still at the mirrors' juncture, will return in the mirrors. Again, by watching over the students' heads and helping them rotate the mirrors, you can help them make the observations. When this new image appears, ask the students to wink the same eye they had previously winked. Voila! The "wrong" eye winks back!

When the mirrors are held at a 90° angle, light reflected from the right side of the face strikes the right mirror at a 45° angle. Consistent with the law of reflection (i.e., the angle of incidence equals the angle of reflection), the light bounces off the right mirror at 45° and strikes the left mirror at 45°. Still consistent with the law of reflection, light is reflected off the left mirror at 45° which sends it directly back to the observer. From the observer's point of view, light that came from the right side of the face emerges from the right side of the image. (We're used to the reverse in a flat mirror.) Likewise, light from the left side of the face forms the image's left side. Crazy! The image in the 90° mirrors is not what we usually see in the mirror (i.e., our mirror image which is a reverse of our real selves) but an image of ourselves as other's really see us!

This quick and mind-capturing use of light and mirrors can be used by the resource people to gain student attention and interest in the behavior of light, even if the resource people do not use reflection as a primary application of light in their career. For instance, people such as opticians who use lenses more frequently apply concepts of refraction, but they use reflection in some of their work and will be able to explain the law of reflection.

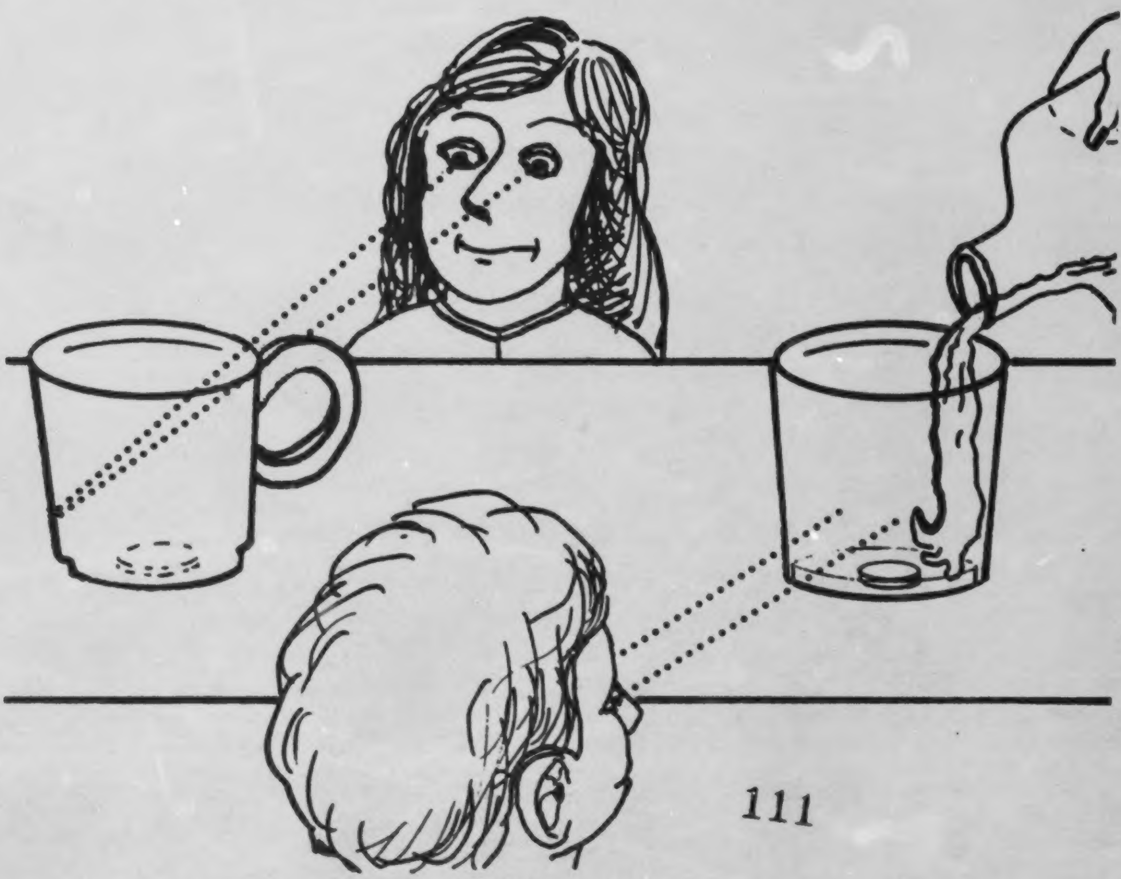
Activity II: Lenses

Materials:

- A clear plastic drinking glass for each student, or if glasses are not available, an opaque cup for each pair of students. The glass should be made so it can straddle a coin placed under it. (This is a good use of used plastic glasses or paper or styrofoam cups. Wash them out and save them.)
- A coin or similar object for each student or pair of students.
- Water.

Procedure (Using Plastic Glasses):

Ask each student to place a coin under the empty plastic glass and observe the coin through the side of the glass. The coin should be quite visible. Then ask them to add water to their cup and continue observing the coin. The coin will soon disappear due to refraction (the bending of light when it passes from one medium to another; from air to plastic to water in this case).



Procedure (Using an opaque cup):

Pair off students and ask them to place a coin in the bottom of an opaque cup. One student should look at the coin and then lower their head until the coin just disappears behind the side of the cup. This student observer should hold their head steady in that position while the second student carefully pours water into the cup without disturbing the coin. The coin will slowly reappear to the observer as the water is added and refracts (bends) the light reflected from the coin. (See illustration on preceding page.)

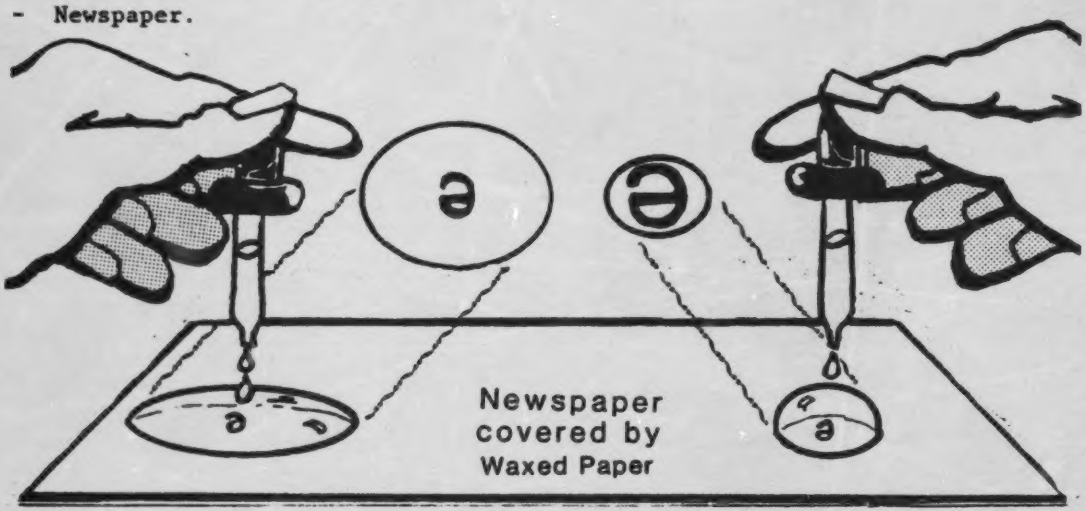
Career Applications:

Each of these activities demonstrates how light is refracted when it passes from one medium to another. That's how lenses work; when light passes from air through the glass or plastic lens and back to air, it is bent. How it is bent depends on the shape and arrangement of the lenses. Microscopes, eyeglasses, cameras, and telescopes all use lenses in different ways, but each lens demonstrates refraction. Depending on the vocation or avocation of your resource people, they should relate their use of lenses to this activity.

Extension Activity 1: Water Lenses

Materials for each Student:

- One piece of approximately 4" x 4" wax paper.
- One medicine dropper or straw.
- Newspaper.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Newspaper covered by Waxed Paper

Procedure:

This activity could be done by the resource people as an extension to the preceding activity or as an alternate activity.

Ask students to spread newspaper on their desks and place their wax paper on the newspaper. Instruct them to place drops of water on the wax paper and observe the newsprint underneath the water. They should vary the size of their water drops and note both the shape and size of the newsprint they observe through the waterdrops. Finally, looking from the side of the drops, they should observe the shape of the various sized water drops and correlate the drops' shapes with the magnification perceived.

They will find that their smaller water drops, which are more rounded than the larger drops, produce greater magnification. These water drops are convex lenses and refract (bend) the light to produce the images that are observed.

Extension Activity 2: Experimenting with Lenses

Material:

- Assorted convex and concave lenses (borrowed from a resource person such as an optician or from school physics lab).
- Printed material for students to observe (e.g,. 1" x 1" sample of newsprint).
- Single letter (E or F work well) printed on a least 8½" x 11" paper and hung within view of students.

Procedure:

This activity takes about 20 minutes or longer depending on student interest and amount of materials available; therefore, it probably should be done following an introduction to refraction by the resource person or teacher. If only a few lenses are available, they could be placed in a learning center to be used by individuals or small groups of students.

Distribute the materials and have students investigate the following questions, observing letters both close up and at a distance.

- Do different lenses make things look different?
- Examine the shape of the lenses. Some are obviously thicker in the middle than at the edges (these are called convex); others are thicker at the edges (concave). Compare the images produced by convex and concave lenses.
- Does it matter whether you hold the lenses close to the eye or further away?

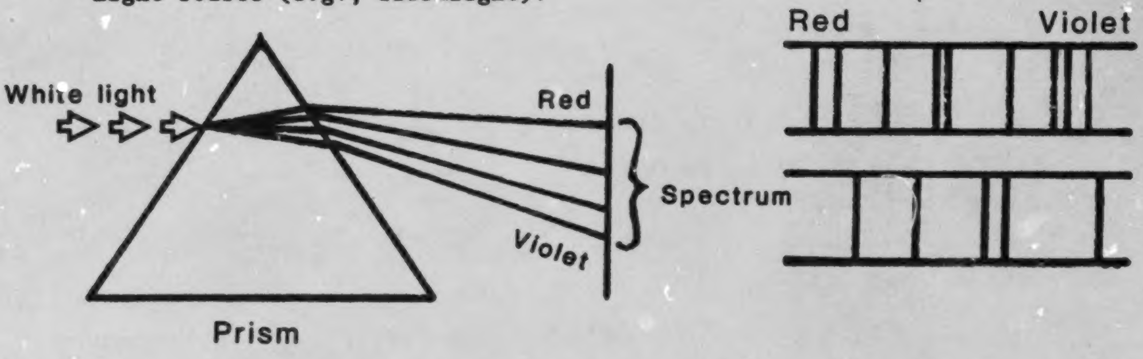
- How do various pairs of lenses work? Make one combination that makes small things look larger and a combination that makes distant things appear closer. (Some students may need prompting to vary both the distance between the lenses and their eyes as well as varying combinations of lenses.)

Especially if your resource person is a photographer, relate at this point the contributions of Barbara Askins to photography.

Extension Activity 3: Prism

Materials:

- Prism and piece of white paper.
- Oil and water (optional).
- Light source (e.g., flashlight).



Procedure:

If a prism is available, shine a bright light through it and focus the light on a white sheet of water. Point out to students how the prism refracted the various components of white light in varying amounts, thus separating the white light into the host of colors making up the spectrum.

If a prism is not available, place a few drops of oil on a bowl of water and shine a light on the water surface. The thickness of the oil on the surface varies, thus making the oil into a prism. (Students may have already seen this phenomenon in a water puddle with some oil floating on it.)

Point out to students that Annie Jump Cannon's classification of 300,000 stars is based on the colors of light they produced. Even though the stars appear to us to all have about the same color, their white light is made up of different component colors, which can be detected by passing their light through a spectroscope which separates the component colors in much the same way as the prism separates white light into the colors of the rainbow.

Extension Activity 4: Spectroscopes

Materials:

- Commercial spectroscope from high school physics teachers or optics supplier such as Edmund listed in bibliography.
- Assorted light sources such as incandescent and fluorescent bulbs, candle flame, or mercury or neon vapor tubes.
- Bunsen burner, propane torch, or candle (optional).
- Heavy wire such as coat hanger with paint burnt off (optional).
- Boric acid or cleaning agent containing borax (optional).
- Table salt or baking powder (optional).
- Cream of tarter (optional).

Procedure:

Following directions which accompany the spectroscope, have students observe a variety of light sources through the spectroscope. Differences may be subtle. Have students pay attention to differences in brightness of various colors in each spectrum. Point out Annie Jump Cannon's use of their spectra to classify stars.

The spectroscope separates white light (or any light) into its constituent colors. By inspecting the colors produced by some material, you can determine the composition of the material. This fact can be illustrated by a flame test.

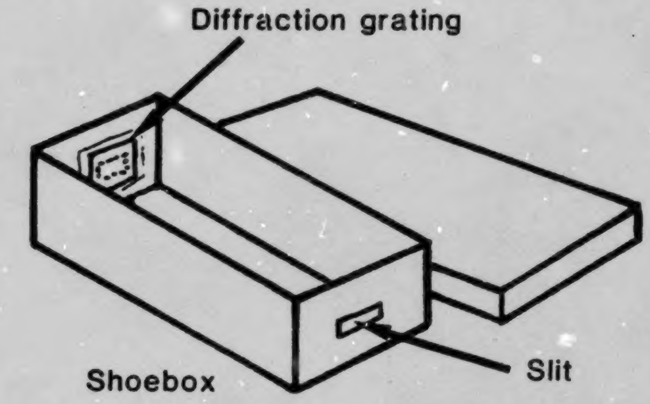
To do the flame test, make a small loop in the end of a wire and burn off any paint present on the wire. Put boric acid, table salt, baking powder, or cream of tarter in the loop and hold it in the flame. (Heat the wire to glowing between materials to get rid of the preceding material.)

The color observed in the flame, directly or through a spectroscope, indicates what material is being heated. Boron (present in boric acid) produces a green flame. Sodium (present in table salts and baking powder) produces a yellow flame not too different than the flame's usual color. Potassium (present in cream of tartar) produces purple sparks. A copper penny held by tongs in the flame produces a blue-green flame. Your high school chemistry teacher may supply other interesting chemicals, such as strontium which produces a beautiful rose flame. (Some of your students may be reminded of substances they've seen added to fireplace fires to produce colors. Indeed, they were looking at a flame test; and they now should be able to guess what materials - copper, postassium, strontium and so forth - had been put into the fire.)

Extension Activity 5: Homemade Spectroscopes

Materials:

- Diffraction grating, either commercial or homemade.
- Shoebox (one for each available diffraction grating).
- Scissors.
- Tape.
- Knife (preferably one used to safely cut cardboard boxes).



Procedure:

Give students these directions for making a spectroscope. Since the boxes take awhile to make, they probably should be made prior to or following a resource person's visit.

Cut a rectangular slit about one inch long by one-eighth inch wide in the center of one end of the shoebox. Cut a rectangular hole to fit the diffraction grating (about 1" by 1") on the opposite end. Tape the diffraction grating over the hole on the inside of the box. Tape on the top of the box. The only way for light to get into the box, except for the observation slit, should be through the diffraction grating, so tape over all other openings. If a commercial diffraction grating is not available, fairly acceptable results can be obtained by scoring clear plastic sheets (e.g., the type used as report covers) with a very fine needle making parallel, straight scratches as close together as possible.

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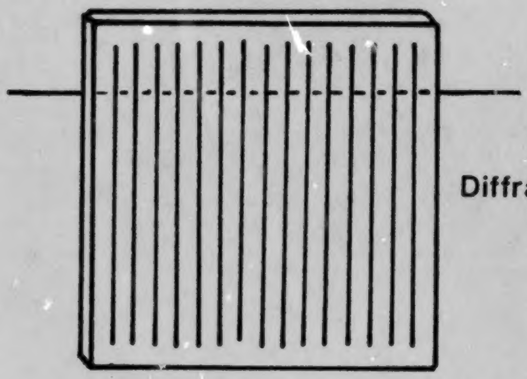
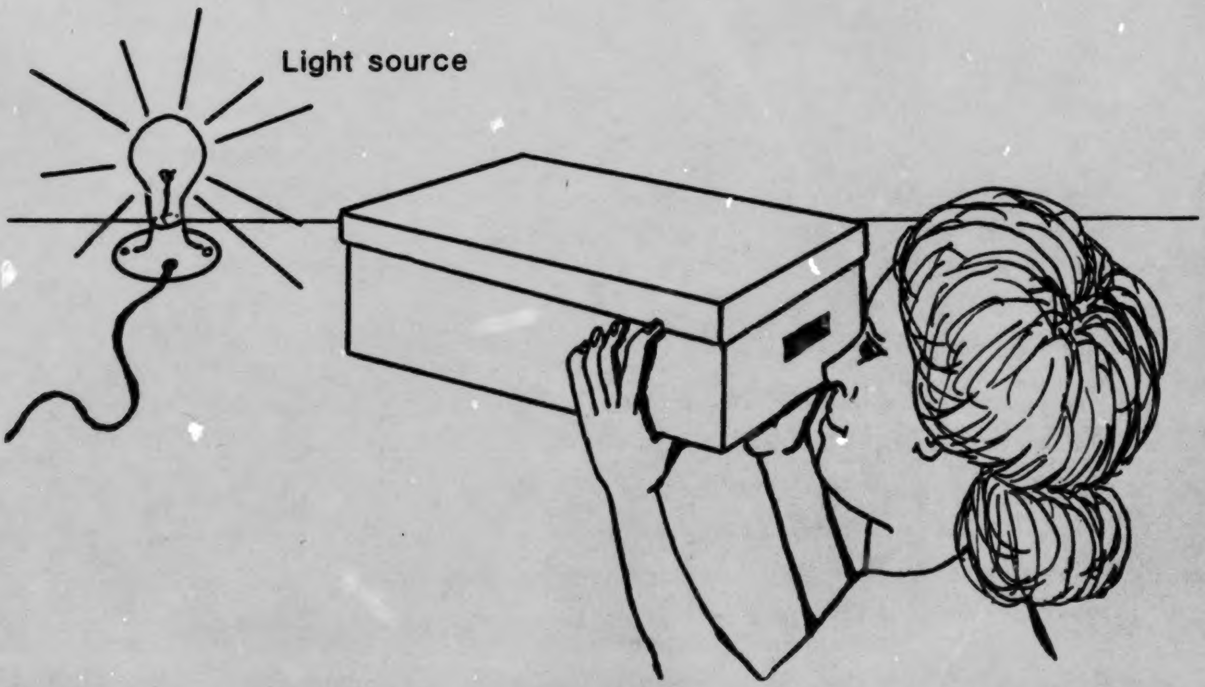

Diffraction Grating

Students can use the homemade spectroscope in the same way the commercial spectroscope is used in extension activity 4.


Light source

Activity III: Illusions

Introduction:

Whereas the preceding activities focused on the behavior of light due to reflection and refraction, this set of activities emphasizes the part the brain plays in interpreting light. The message is that the brain and eyes do as well as they can to provide us a true picture of reality, but we must recognize that our perceptions are only an interpretation of reality. Sometimes our perceptions are entirely incorrect; and in fact, our perceptions never precisely correspond with reality.

These activities are particularly appropriate for visual specialtists such as optometrists, ophthalmologists, and opticians. They may choose to use one or more of the activities to initiate their visits with students.

The resource person or teacher may distribute COMETS Challenge Cards to students based on these activities. Even if the Challenge Cards are not used, you can refer to them to clarify the written directions.

Activity 1: Extra Fingers

Materials:

- Challenge Card.

Procedure:

Ask students to put their forefingers together, tip to tip, and to hold them at arm's length directly in their line of sight. (See Challenge Card.) Ask them to relax their eyes and to focus them at a distance. They should not focus on their fingers, but the fingers should remain visible to them.

As their eyes relax, the students should see the two forefingers separated by a hot dog shaped "finger." This extra finger is formed by the brain which receives the unfocused message from each eye and tries to put those messages together as well as it can. The "hotdog" can be removed by focusing the eyes on the fingers. The focused message from each eye allows the brain to clear up the image it produces.

Activity 2: Fishing

Materials:

- A 3" x 5" or similar sized index card with a fish drawn on one side of the card and a fish bowl on the other side. (See Challenge Card.)

Attach a rubber band to each side of the card, using a staple or tape, or threading a rubber band through a hole on each side of the card and looping one end of each rubber band back through the other end.

Procedure:

Distribute as many of these cards as possible to students, so each can do the activity, or have them make the cards. Direct them to hold the rubber bands in each hand and wind up the card like a paddle wheel. When they have wound up the card, they should pull on the rubber bands. If the cards flip around rapidly, they should "see" the fish in the bowl.

The fish appears inside the bowl for the same reason that we see a motion picture as continuous motion rather than as a series of separate snapshots. Our eyes and brain can process images only so rapidly. As the rate at which images are presented to the eyes increases, the brain blends the images together.

Activity 3: Mouse/Person?

Materials:

- Challenge Card. (It can be made into a transparency for an overhead projector, if desired.)

Procedure:

Show students the outline of the mouse/person and ask them what they see. Some will see a mouse, whereas others will see a silhouette of a person's head with large glasses.

You can control more precisely what they see by asking them not to say anything until called upon. Tell them they're about to see a person's head and that they should think or write down as many characteristics of this person as they can. Emphasize that they are about to see a person. Then flip the mouse/person on the overhead while simultaneously reminding them not to say anthing. (Most will see the silhouette, but a few will see the mouse. Some will see both.) Then turn off the overhead and tell students they will next see an animal, a small squeeky animal. Shuffle your papers to make it appear you are putting a new image on the overhead; and then turn on the projector to show the mouse/person. Help those who are unable to do so themselves to see both images. Some will never be able to see two images.

This activity illustrates again the role the brain plays in interpreting what we observe. In this case, students can be introduced to how strongly our brains are influenced by the mindset we have when making an observation. We generally "see" what we expect to see. (As an extension of this activity, show the film Evidence, part of the Search for Solutions series. See bibliography.)

Activity 4: Size Cues

Materials:

- Challenge Card with figures composed of straight lines.

Procedure:

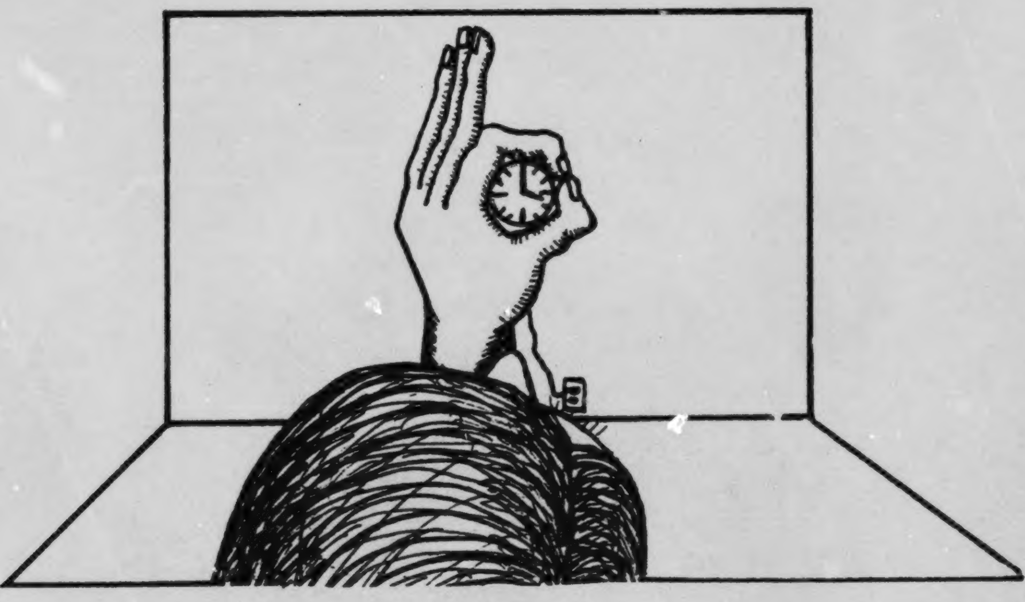
Show students the COMETS Challenge Card or draw the figure on the blackboard or overhead. Ask, "Which horizontal line is longer?" Almost invariably observers will report the top line is longer, even though both horizontal lines are equal.

This activity illustrates that the brain interprets visual cues in order to judge the size and position of objects. How the brain does the interpretation is open to question.

Activity 5: Centering

Materials:

- None.



Procedure:

Ask students to make a circle by placing the tip of their index finger to the tip of their thumb. While keeping both eyes open and extending their hand at arm's length, they should center a distant, distinct object (e.g., a room clock) in this circle. (See illustration on preceding page.) Without moving their hand they should alternately close each of their eyes. They usually will observe that unbeknownst to themselves they have centered the distant object with either the right or left eye, but not both.

As this activity demonstrates, just as most people are righthanded or lefthanded, most people are righteyed or lefteyed. Our brains have a preferred side through which to focus on the world. Increasing attention has been paid to this apparent preference by investigators who study right brain/left brain phenomena.

Activity 6: Blind Spot

Materials:

- One index card for each student. They should draw a circle (size of a penny) and an "X" about 3" or 4" apart on the card.

Procedure:

Ask the students to hold their cards at arm's length and with one eye closed slowly bring the card closer to their eyes while they focus on the circle. At some point the "X" should disappear and then reappear as the card is brought even closer.

This phenomenon of the disappearing "X" is due to the eye's structure. At the point where the light from the "X" becomes focused on the part of the eye where the optic nerve is connected, the "X" will disappear because at that point (the blind spot) there are no nerves to perceive the light.

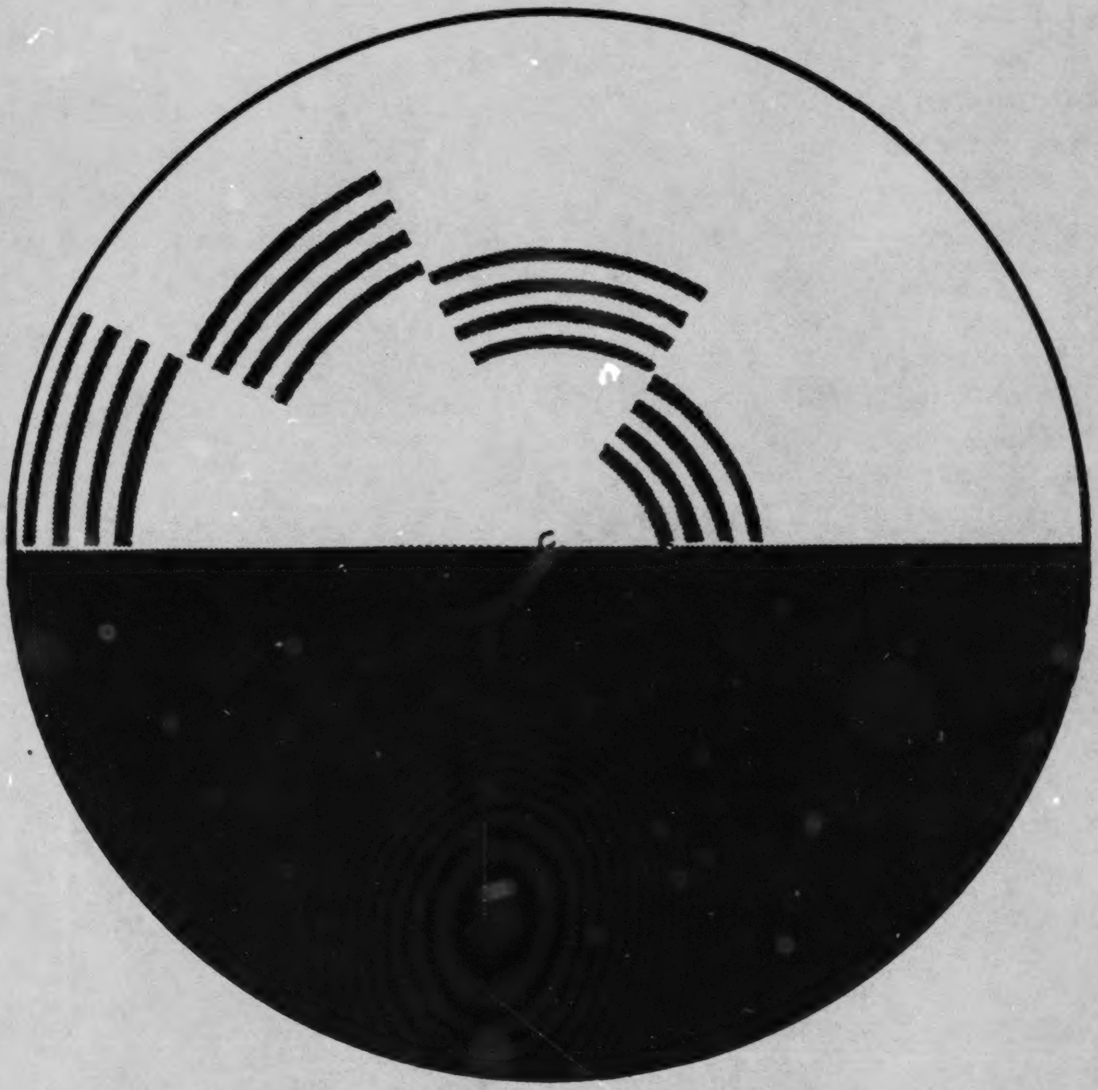
This activity can be related to "Spare Parts" in Body Detectives which directs resource people to dissect body parts and point out their structural features and functions.

Activity 7: Spinning Wheel

Materials:

- A heavy circular card with the black and white drawing on page 19 glued to it. Punch a hole in the center of the card. This drawing can be photocopied and given to each student.

- A heavy wire from which to suspend the card. A bent out paper clip works well.
- A variable speed electric drill (optional).



Procedure:

Direct students to suspend the card from the wire and rapidly spin the card. Some practice will be necessary. Do the activity in as bright light as possible. As they observe the card they should see shades of color (especially red, blue, and green) instead of just greys. These colors will vary as the card slows down.

The card can be attached to a drill with a bolt, nuts, and washers (to hold the card snugly while spun by the drill). Vary the drill's speed and observe the colors on the card.

The nerves in the retina of the eye perceive color by the frequency of the light which strikes the nerves. Due to the varying proportions of black and white in the concentric rings on the card and the varying rate at which the card spins, the eyes will be stimulated at varying rates by alternating black and white. Thus, the brain "thinks" that each part of the card is reflecting light of differing frequencies and it interprets this message as differing colors.

Careers In Sight

About half of all Americans use some kind of corrective lenses; and as the American population ages, the number of people using these lenses undoubtedly will increase. Thus, a large occupational area with several different specialties has developed and will continue to grow to meet these needs.

America's 21,000 optometrists examine people's sight and prescribe corrective lenses and/or treatment. If the patient's visual problems involve disease such as glaucoma and/or require certain specialized treatment such as surgery, the optometrist will refer the patient to an ophthalmolgist, a physician who specializes in eye care. (See Fit N' Trim for career information about physicians.) Most optometrists are in general practice, but some may specialize in certain age groups or particular eye problems. Eyeglasses and contact lenses are often dispensed through their office; or the optometrist's prescriptions for lenses may be filled separately by dispensing opticians. Optometrists earn a Doctor of Optometry degree (O.D.) by completing at least six to seven years of college training, including two to four years of preprofessional coursework and four years of professional training in one of 13 accredited schools. They must then pass a licensing examination prior to practice. Their coursework emphasizes math and science; but since O.D.'s often practice privately, they also need small business skills, and they must be adept in dealing with patients.

The dispensing optician, of whom there were 17,500 in 1978, takes the optometrist's or ophthalmologist's prescription for lenses and fits the patient for eyeglasses. In some states they can also fit contact lenses. The dispensing optician, or optician for short, usually sends the prescription for lenses and frame measurements to an eyeglasses manufacturer; but the eyeglasses may be made in the optician's place of business. Opticians must complete two to four years of apprenticeship following high school graduation; or they may receive training in one of 21 accredited two year training programs. Their high school coursework preferably should include some basic science (biology and physics), math (algebra and geometry), and mechanical drawing. Opticians, like optometrists and ophthalmologists, must work well with patients and, if they establish their own business, have small business skills.

The optician's high school and apprenticeship background is similar for the 26,500 ophthalmic lab technicians (lens technicians for short). However, the lens technician must use machinery and work to exacting specifications in making the eyeglasses or contact lenses. Also, the lens technician does not come into contact with patients.

Careers In Photography

People who take and develop still and motion pictures work in a variety of settings and possess a variety of experience and educational backgrounds. Currently there are 93,000 photographers who work independently or in commercial or industrial settings. Many photographers have a high school education plus on-the-job training, but additional specialized training can be obtained in undergraduate or graduate schools. Varying degrees of science background are required, depending on the photographer's specialty, but an understanding of optics and the chemistry of photographic development is very useful.

Approximately 57,000 photographic laboratory workers are employed to develop still and motion pictures. High school graduation plus on-the-job training are usually required. A knowledge of basic chemistry and optics is considered useful for the trainee.

Bibliography

Related Activities and Topics:

Asimov, Isaac. *How Did We Find Out About Black Holes?* New York: Walker and Co. 1978.

How Did We Find Out About Comets? New York: Walker and Co. 1975.

How Did We Find Out About Outer Space? New York: Walker and Co. 1977.

Edmund Scientific Corporation, 101 East Gloucester Pike, Barrington, New Jersey 08007.

Edmund markets a host of lenses, prisms, and other optical delights.

Evidence. Part of the Search for Solutions film series available free from Playback Associates, 708 Third Avenue, New York, New York 10017.

This series is excellent both in its portrayal of the scientific investigative enterprise and its inclusion of women, minorities, handicapped, and people of many nationalities. *Evidence* emphasizes the role of the brain in interpreting the data our eyes receive.

Optics. Published by McGraw Hill Book Company, 1221 Avenue of the Americas, New York, New York 10020.

A teacher's guide and optional, but recommended, equipment; suggests many fascinating activities.

About Women and Light:

Bourke-White, Margaret. Excerpt from *Portrait of Myself* in Ross, Pat (Ed.), *Young and Female*, New York: Random House, 1972, pages 91-104.

This biographical sketch of how Bourke-White began her photographic career includes a reference to her science background. *Young and Female* excerpts autobiographies of eight women successful in many areas.

Urban and Rural Systems Associates. *An Exploring Study of Women in the Health Professions Schools*. Washington, D.C.: Women's Action Program, Department of Health, Education, and Welfare (Contract HEW 05-74-291), 1976.

This most interesting series contains information not only about women in each health career, but also the history of the professions themselves. Since changes are occurring rapidly in these fields, the statistics are somewhat dated, but the general principles remain. Somewhat difficult to obtain, this series is a good resource for the teacher who wishes to delve into further study.

References are made in "Women and Light" to biographical material.

COMETS Profile:

Any of the Profiles of physicians would provide insight in the ophthalmologist's and optometrist's careers.

For More Career Information Write:

American Optometric Association, 243 N. Lindbergh Blvd., St. Louis, Missouri 63141.

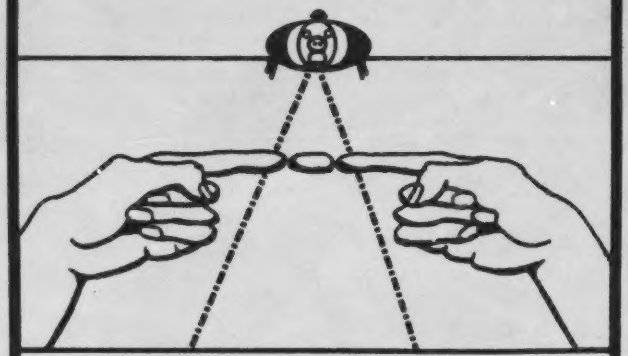
National Academy of Opticianry, 514 Chestnut St., Big Rapids, Michigan 49307.

Opticians Association of America, 1250 Connecticut Avenue, N.W., Washington, D.C. 20036.

Professional Photographers of America, Inc., 1090 Executive Way, Des Plaines, Illinois 60018.

COMETS Challenge Cards

Touch index fingers and hold them at arms length in front of your eyes.
Focus your eyes on a distant object while looking through your touching fingers.
A weiner-shaped finger should appear between the ends of your fingertips.

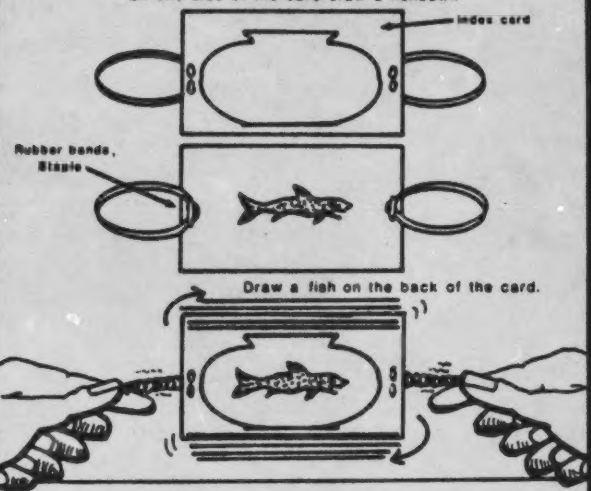


Light and Sight

How many fingers can you see?

COMETS Challenge Cards

On one side of the card draw a fishbowl.

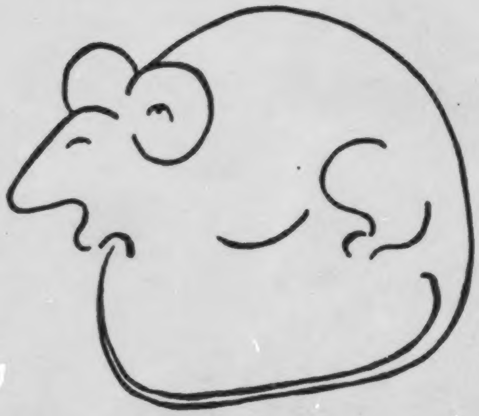


Attach rubber bands and wind card up until the rubber bands are tight. Let the cards spin. What do you see?

Light and Sight

How can you get the fish into the bowl?

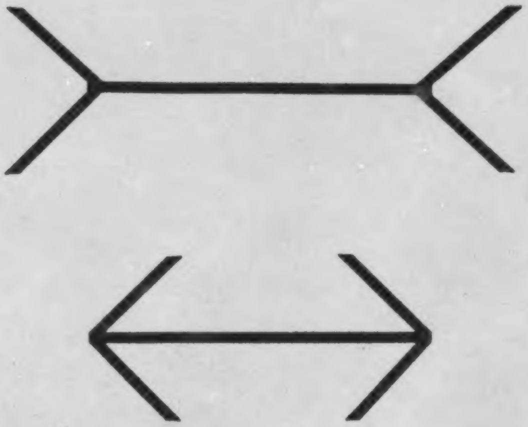
COMETS Challenge Cards



Light and Sight

Do you see a mouse, or a human head, or both?

COMETS Challenge Cards



Light and Sight

Which horizontal line is longer? Are they the same length?

Career Oriented Modules to Explore Topics in Science

COMETS

Misc. Materials

TOPICS

- Properties of Matter
- Metals
- Rocks

RESOURCE PEOPLE

- Metallurgist
- Geologist
- Artist

THIS MODULE

Activity I

In "Crystal Garden" students make and/or observe crystals, thus learning how crystals are comprised of small particles (atoms and molecules) structured in a regular pattern. The first activity is brief, but requires some special equipment. "Shadows" is brief, requires simple equipment, and can be related to the work of Dorothy Crowfoot Hodgkin and Rosalind Franklin, whose crystallographic work provided necessary evidence for unraveling the structure of DNA and other organic molecules. "Growing Crystals" takes several days and requires simple equipment. Geologists and metallurgists are good resource people for all these activities.

Activity II

"Bendability" demonstrates this property of metals, shows one effect of heat on metals, and allows students to operationally define a variable (bendability) and collect and interpret data. The first activity is variable in length, but may be quite brief. The extension activity is longer and employs some special, but simple, equipment. Some caution is necessary in the extension activity due to the use of heat. This activity is especailly appropriate for materials scientists such as metallurgical or ceramic engineers or for artists who work with metals or ceramics.

Activity III

"Caramel" is another demonstration of the effect of temperature on the properties of the product being made. Candies of different consistencies are made by varying the temperature of the initial syrup. This activity is probably best done as a demonstration because of the use of heat. Materials are simple but some special effort may be needed to gather them.

University of Kansas School of Education Department of Curriculum and Instruction

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RELATED MODULES

All activities in this module are intended primarily for materials scientists, especially metallurgical and ceramic engineers and metallurgists. Geologists can be used as resource people for "Crystal Garden," artists can be used in "Bendability," and home economists can be used in "Caramel."

Product Improvement

Students do activities, such as making glurch or paper, which demonstrate how the production process is manipulated by engineers to obtain the desired product.

Pearly Gates

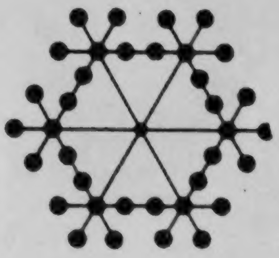
Students study the effect of acid on carbonates (e.g., dissolve egg shell in vinegar) in order to simulate the effect of acid on their own teeth.

Energy

More applications of the production and movement of heat energy can be found in that module.

WHERE TO FIND RESOURCE PEOPLE

Local industries which manufacture metal or ceramic products would be a good place to find resource people. For references call your Chamber of Commerce. Don't limit yourself to the heavy manufacturers such as steel mills. For example, dental technicians, in preparing bridges, crowns, caps, and false teeth, use a variety of materials which require handling at different temperatures. Check the yellow pages under welding. An industrial arts teacher may make references for you. A local arts council, art teacher, or art shop may refer you to artists working in metals or ceramics. The state or federal geological survey could be contacted for geologists.



Women and Crystallography

Dorothy Crowfoot Hodgkin won the Nobel Prize, Rosalind Franklin didn't; but the work of both scientists contributed to fundamental improvements in our knowledge of the structure of important biological compounds. Hodgkin unraveled the three dimensional structure of vitamin B_{12} and penicillin, leading to both a better understanding of how these compounds work and an ability to synthesize them, rather than relying on the much more costly process of extraction from natural sources. Franklin made measurments of the spatial relations of atoms within DNA (deoxyribonucleic acid). Her evidence, along with information and ideas from other sources, was woven together by Watson and Crick who formulated the double helix DNA model on which much biochemical work of the last quarter century has been based.

As crystallographers, Hodgkin and Franklin applied x-ray diffraction, a process where x-rays are bounced off the atoms making up a crystalline compound. The diffracted ("bounced") x-rays expose photographic film. The pattern produced on the film can be used to determine the three dimentional positioning of atoms within the crystal. Analogously, in "Shadows," Extension Activity 1 in Activity I, students look at shadows cast by solids; and from these shadows they determine the shape of the solid. With careful measurement, not only the shape of the solid (e.g., cube or cylinder), but also the dimensions of the solid can be revealed. Crystallographers figure out the overall shape and dimensions of a compound; and they also determine where particular atoms are located within the compound. For instance, Hodgkin figured out the overall shape of the B_{12} molecule, $C_{63}H_{88}O_{14}N_{14}PCo$, and the positioning of each of its 181 atoms. (Of course, she applied knowledge of organic chemistry - where one might expect to find the atoms - to the concrete data she had collected.)

For her work in structural chemistry, Dorothy Crowfoot Hodgkin was awarded the Nobel Prize; but Rosalind Franklin didn't receive the coveted prize, even though without her work Watson and Crick couldn't have deciphered DNA. Franklin's situation pointedly reveals one source of problems and controversy women have encountered in research science. Franklin worked in a laboratory with Maurice Wilkins. The controversy revolves around that preposition, "with." Did she work "for" Wilkins or did she work as "a colleague of" Wilkins? Consistent with Watson's account of the stiuation in Double Helix, the Nobel Prize committee concluded that Wilkins oversaw the crystallographic elucidation of DNA and made him a co-recipient along with Watson and Crick of the Nobel Prize. In their view Franklin was seen as a subordinate of Wilkins and thus the award belonged to him. In Rosalind Franklin and DNA (see Bibliography), published subsequent to Franklin's death, a well documented case was made for Franklin's having done the crystallographic work independently of Wilkins; and thus she should have shared the Nobel with Watson and Crick.[1]

The Franklin-Wilkins "whodunit" makes fascinating reading not simply because it reveals the situation of women as researchers but also because it exposes scientific research as a totally human endeavor filled with strong emotions and deep interpersonal feelings. The Sayre, Watson, and Kammer books listed in the bibliography make fascinating reading for a new perspective of what it takes to be a scientist; and these books are recommended for the teacher's reading.

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[1] Franklin's situation is not unique. Eli Whitney did not invent the cotton gin. Beatrix Potter (of Peter Rabbit fame) figured out that lichens are a symbiotic association of algae and fungi; but few would listen to a woman, so she went to work as an illustrator and writer. (Science's loss was children's literature's gain.) The idea of pulsars came out of data collected and recognized as something special by Jocelyn Bell Burnell; but she did her work in the laboratory of Anthony Hewish and Martin Ryle and they were credited with being the discoverers of pulsars, winning the Nobel Prize in the process. The point is not that women have made all the scientific discoveries. The point also is not that women scientists work in a vacuum independent of men. No, the point is that in many instances women have been viewed by others (and sometimes themselves) as subordinates; and thus their very real contributions have been unrecognized, leaving each generation with the mistaken impression that women haven't done anything in science.

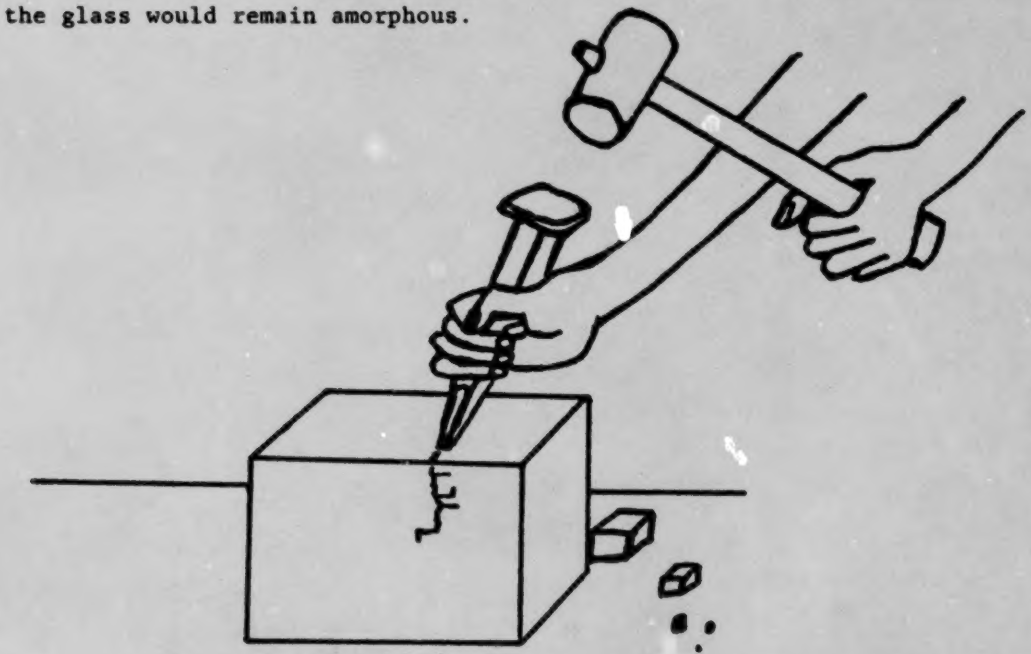
Activity I: Crystal Garden

Materials:

- Salt (NaCl) crystal.
- Piece of glass.
- Other crystals, if available.
- Rag.
- Hammer and chisel.
- Hand lenses.
- Newspaper.

Procedure:

This activity should be done as a demonstration by a professional or amateur geologist or metallurgist to point out the crystalline structure of salt (NaCl) versus the amorphous structure of glass. Before breaking the salt and glass, have students compare the properties of the two materials. Select volunteers to look at each piece with a hand lens. Then carefully break each piece with a hammar and chisel. (A rag can be gathered around the salt and glass to catch splintered chips. Goggles should be worn.) Again ask students to observe the pieces with the naked eye and hand lens. Continue this process until pieces are too small to be broken. Students should be able to predict that if one could continue breaking the pieces, the salt would remain cubic whereas the glass would remain amorphous.



At this point other crystals can be shown and discussed by the resource person. The point should be made that crystals are composed of atoms of elements structured in some regular three dimensional pattern reflected in the larger crystal.

Extension Activity 1: Shadows

Materials:

- Overhead projector.
- Several cubes (e.g., building blocks or sugar cubes).
- Cylinder (e.g., juice can).
- Ball (e.g., golf ball).
- Several flashlights (as many as possible; students could be asked to bring them from home).

Procedure:

This activity can be done independently or as an extension of the previous activity. Place the cylinder or the ball on the overhead projector in various positions to reveal the solid's various shadows. Students should connect the two dimensional shadows with the three dimensional solid and state that the three dimensional shape of an object can be inferred from its shadows.

Pass out blocks and flashlights, grouping students according to how much equipment is available. Ask them to cast a square shadow on the desk or floor. (They should be able to do so by shining a flashlight perpendicular to one face of the cube. They should experiment to find how to best focus their shadows.)

Then ask students to make a rectangle. (This can be done by shining the flashlight perpendicular to one edge of the block. Two sides of the rectangle will equal the length of one edge of the cube; and the other two sides will equal the length of one edge of the cube times $\sqrt{2}$. Students may have to use a ruler to satisfy themselves they've made a rectangle.) Finally challenge them to make a hexagon. (This can be done by aiming the flashlight at one point of the cube.)

At this point relate the work of Dorothy Crowfoot Hodgkin and Rosalind Franklin, crytallographers whose work led to the unraveling of the structure of DNA (Franklin) and of numerous organic compounds, including vitamin B_{12} (Hodgkin). Instead of light, these two women used x-rays, another type of radiation, to form a shadow from specially prepared samples of the material. Just as students (1) had to "play around" to figure out how best to focus the shadows, (2) were able to produce several shadows, depending on the relationship of the light source to the cube, and (3) could interpret the shadows to figure out the shape of the solid, these women did the manipulation and brainwork required by scientific investigation.

Extension Activity 2: Growing Crystals

Materials:

- Two pyrex beakers (500 ml, about one pint) or other heat resistant containers.
- Hot plate or candle.
- Water.
- String.
- Two small nails.
- Hot pads and clamps for holding hot beakers.
- Bucket of ice.
- Hand lenses.
- One or more of the following: borax, epsom salts, kosher salt, sugar, alum. (If different groups use different salts, comparisons can be made. Epsom salts, borax and alum can be obtained at drug stores; and kosher salt can be obtained at stores which sell kosher foods. Your high school chemistry teacher may give you samples of other salts such as copper sulfate which produces a striking, blue crystal.)

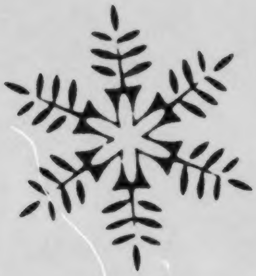
Procedure:

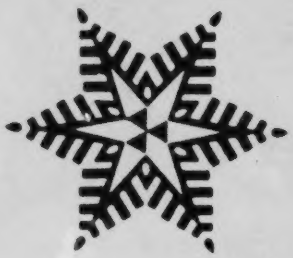
Since this activity takes several days, it should be started well ahead of or following the resource person's visit. Equipment should be divided among groups of students to the extent possible. Caution students about the equipment's use.

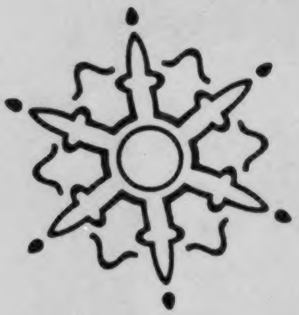
Instruct students to put one teaspoon of one of the salts in a beaker half-filled with water and to heat the mixture until it starts a gentle boil. Add a half teaspoon more of the same salt, mix well, and then pour half of this mixture into an identical container. Hang a small nail from a string and suspend it into the hot solution in each container. (The string can be suspended from a pencil laid on the top of the beaker.) Allow one container to cool at air temperature. (Store where it will be undisturbed.) Put the other beaker in a bowl of ice. (It's very important that the beakers be heat resistant so they won't break under these conditions.)

Leave the beakers undisturbed overnight and then make comparisons. Observe number, shape, and condition of the crystals, using the hand lens. Additional observations can be made periodically for the next several days. Students may be disgruntled about the crystal's slow growth. If so, remind them that atoms are so small that hundreds need to line up each second for a crystal to grow one inch in a month!

If students live in an area with snow, remind them that snowflakes are crystalline water droplets. While no two snowflakes are precisely identical, they all have a hexagonal crystalline shape.







Extension Activity 3: Snowflakes

Materials:

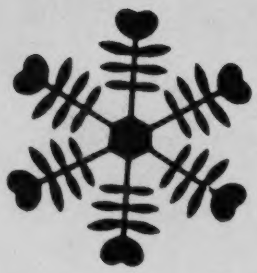
- Glass microscope slides.
- Spray lacquer.
- Pinch type clothes pin.
- Hand lens or microscope.
- Snow!

Procedure:

This activity probably should be done following the resource person's visit, since it requires falling snow. Who can count on that when you want it?

Chill the slides. When the snow starts to fall, go outside with the chilled slide held by a clothes pin (so your body heat won't warm the slide). Spray the slide with a thin layer of lacquer and then catch a few snowflakes on the slide. Leave the slide in a cold, protected place for one hour. (It's best to leave the slide outside rather than in the refrigerator. The trip indoors will melt the flake.) After one hour, bring the slide inside and examine the snowflakes' imprint in the lacquer, using a hand lens or microscope.

If you do not live in a snowy region and would like to try this activity, contact a teacher in a snowy climate and offer to exchange something such as local rocks for the snow slides.



Activity II: Bendability

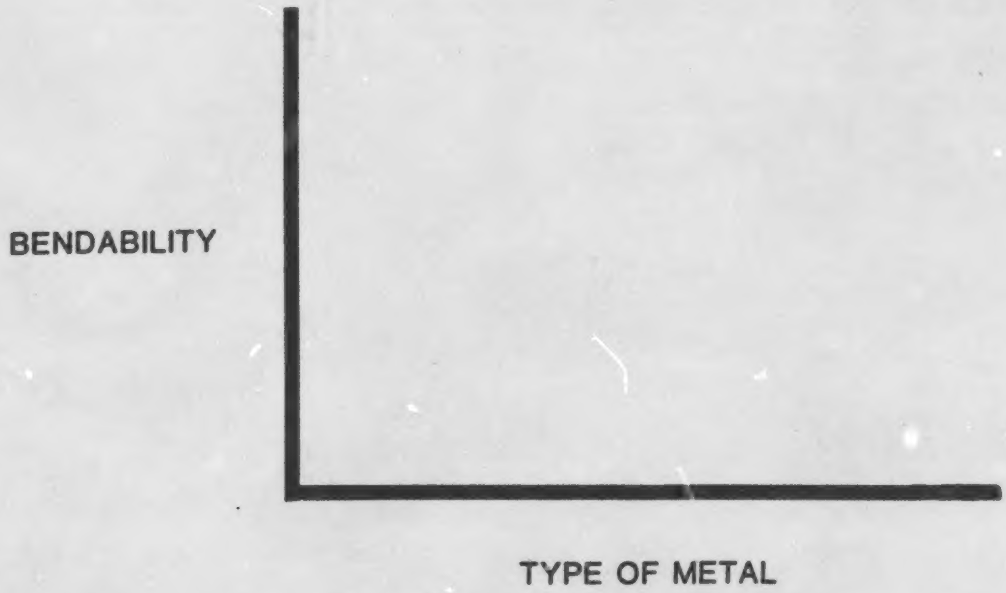
Materials:

- Assortment of metal wires of various compositions and sizes (e.g., bare wire, picture hanging wire, solder, bobby pin, paper clip, aluminum wire, and/or any other wire you and/or your students can find).

Procedure:

This activity can be done as a fairly rapid demonstration of how bendability varies among metals; and/or students can do the extension activities in which they collect, graph, and interpret data over a 30 minute period or longer.

Have students decide on a test of bendability (i.e., they will operationally define the term). Perhaps the easiest test is counting the number of times the wire can be bent from a straight angle (180°) to a right angle (90°) and back without breaking. Then have students apply this test to an assortment of metals. (If sufficient materials are available, individuals could test several metals; or each student could test a different metal.) Have students pool data. Record both the average values and the range of values (e.g., the paper clip broke after 14 to 23 bends with the mean being 17.2 bends). Results can be summarized in a bar graph and comparisons made between types of metals and different forms of the same metal.



The resource person (e.g., a metallurgist) could comment on why bendability varies (e.g., due to treatment of the metal during manufacturing) and how this knowledge is applied to produce metals to fit varying specifications.

Extension Activity 1: Heat Treatment

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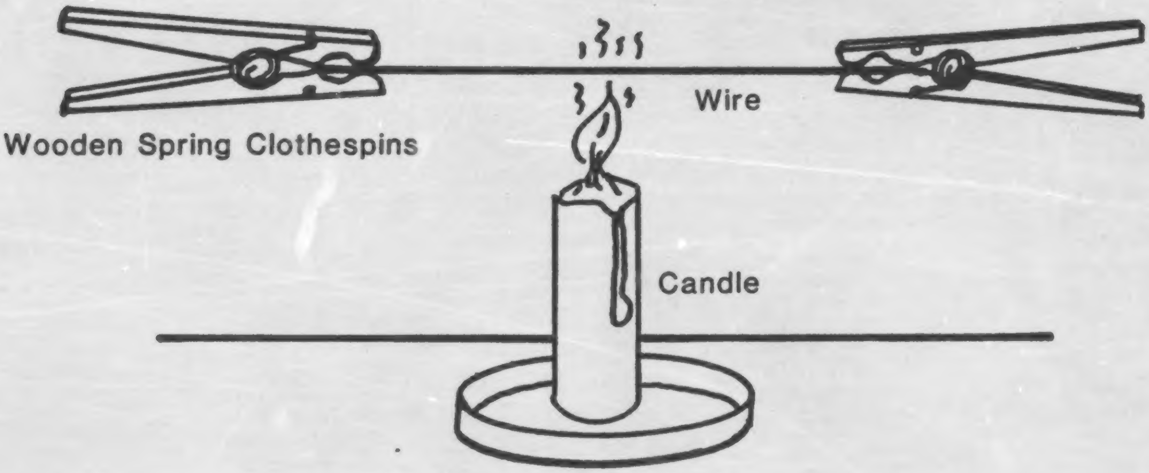
Materials:

- Candle, alcohol burner, propane torch, or bunsen burner.
- Clamps to hold wires. (Wooden pinch-type clothespins work well, since wood doesn't conduct heat very well - something good to point out to students in this activity - and they're available rather inexpensively.)
- Assortment of metal wires. (See preceeding activity for suggestions.)
- Containers of water.
- COMETS Challenge Cards (optional).

Procedure:

This activity should be done following the preceding activity where students compare the bendability of various metals. Demonstrate proper use of the heat source that is available; and alert students to safety precautions. Distribute metals and wooden clothespins to students to the extent materials are available. With limited supplies this activity may be done individually in a learning center and followed by a class discussion and resource person visit. The Challenge Cards may be used to raise questions for investigation.



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Using wooden clothespins, hold the wire in the flame until it glows red hot. Immediately dip the metal in cool water and hold it there until its temperature stabilizes and the metal can be touched. Next perform the bendability test devised in the preceding activity. Again graph the data; then compare types of metals, different forms of the same metals, and the heat treated versus untreated forms of the same metal.

- Does the heat treated metal perform the same as the untreated metal?
- Can you make any generalizations about the effect of heat treating all metals, or does the effect of heat vary among metals?
- Does the length of the heat treatment affect bendability?

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Activity III: Caramel

Introduction:

Making candy may seem out of place in a module for metallurgists and related career people; but several important concepts can be demonstrated through candy making, and students can also end up with a tasty treat. As anyone experienced in making candy can tell your class, the temperature is all important. By varying only the temperature of the syrup from which candy is made only slightly, you can get anything from ductile strings to brittle lumps, thus demonstrating how the temperature of a material affects its properties. Here's what the Joy of Cooking (Rombauer, I. S. and Becker, M. R., Indianapolis: Bobbs-Merrill, 1963) says happens when a small quantity of syrup is dropped into ice water. (Make syrup by dissolving two cups of sugar into one cup of water. Then heat this solution in a saucepan. Spoon a small amount of syrup into ice water with a long handled, wooden spoon. Watch for splattering.)

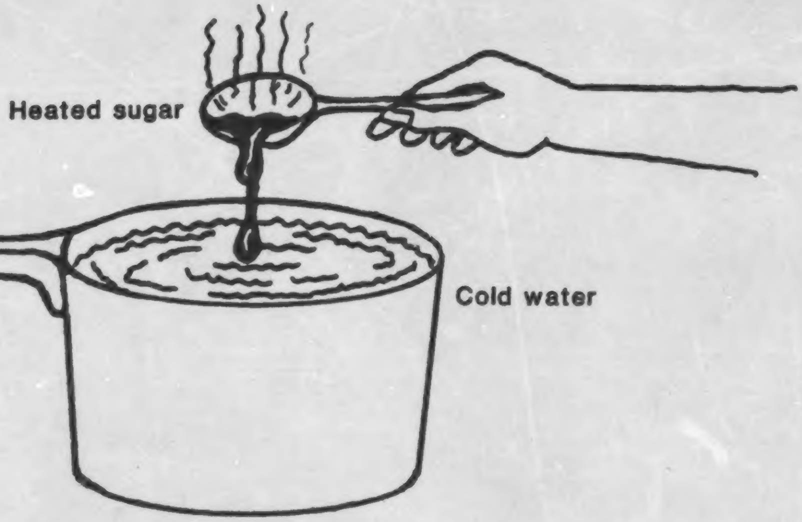
Temperature, °F, of Syrup Before Dropping in Ice Water	Property of Cooled Sugar
230° - 234°	Coarse thread (thread).
234° - 240°	Ball which flattens of own accord when picked up with fingers (soft ball).
242° - 248°	Ball will hold its shape unless pressed with fingers (firm ball).
250° - 268°	Ball will hold its shape but is still pliable (hard ball).
270° - 290°	Hard threads, which when removed from water, will bend and not be brittle (soft crack).
300° - 310°	Hard threads which are brittle (hard crack).
310° - 338°	Sugar begins to turn golden brown (carmelize) but will not turn black until about 350°.

G

(Activity III)

Materials:

- Sugar.
- Water.
- Hot plate.
- Small saucepan. (Since this pan is going to become rather hot, it should have a non-metallic handle.)
- Container of ice water. (Preferably container should be made of pyrex or other heat resistant material.)
- Long handled wooden spoon.
- Candy thermometer.



Procedure:

This activity probably should be done as a demonstration. If it's done by students, it should be closely supervised, due to the danger of burns.

Into a cup of hot water in a small saucepan pour about two cups of sugar, stirring constantly, until no more sugar will dissolve. (If you use a larger saucepan, increase the amount of water and sugar.) Heat the syrup to 232°F. (Measure the temperature of the syrup with a candy thermometer held in the middle of pan.) When the syrup has reached the proper temperature, carefully pour a spoonful into ice water. Watch for splashing. Observe the resultant sugar. Raise the temperature of the saucepan of syrup to 236°F and drop a spoonful into ice water. Continue heating the syrup to temperatures listed on the table and drop samples of syrup into the ice water. Save, label, and compare the products made at each temperture. (The remaining caramel is great on ice cream!)

The differences in properties of the various cooled syrup samples are due to differing crystalline structures that form when the syrup is cooled rapidly from each temperature. The metallurgist or other materials scientist should relate this effect of temperature on the form of candy produced to the effect of temperature on the type of steel, or other material produced in their manufacturing processes. Artists who work with metals and ceramics can also relate this activity to the effect of heating in their media.

If there's time, it's interesting to speculate with students whether the resultant product in candy making is a solid or a liquid. The soft ball, for instance, seems firm (like a solid); but while it sits there, it spreads out and takes the shape of its container (like a liquid). In fact, given time (in some cases, years), each of these candies would lose their shape, indicating that they are each liquids. Indeed, many materials (e.g., soap, glass, rubber) which we think of as solids are really liquids. Our everyday notion of solids and liquids becomes muddied and breaks down on closer inspection. For most of us, whether something is a solid or a liquid makes little difference to us; but to a materials scientist (e.g., ceramic or metallurgical engineer), the form of the material and how to produce that form is a vital question. ("Glurch," an activity in Product Improvement, applies this solid/liquid question to a fascinating material made of starch, glue, and salt.)

Career Information

Refer to the module, Product Improvement, for career information about engineering, which covers the 16,000 metallurgical and 14,000 ceramic engineers who are the primary resource people for this module. Career information about geologists is described in Soil.

Metallurgy is nearly as old as human civilization, for early on people learned to extract and forge metals from ores. Their modern counterparts, the metallurgical and ceramic engineers and scientists, continue their work in a more sophisticated fashion. The extractive metallurgist's job is to get the metal out of the ore (after the mining engineer and cohorts have gotten the metal out of the ground). Physical metallurgists concentrate on the properties and uses of metals themselves. They work at improving metals to do whatever job is required. A materials scientist's work is not limited to metals, but also embraces ceramics, plastics, plant extractions (e.g., rubber), and so forth.

In addition to college educated materials scientists, thousands of others work in metals and ceramics as, for example, patternmakers in foundries, machinists, or glass blowers. Some of these workers do not need a high school diploma; but high school graduation is preferred for most on-the-job training or vocational training programs. High school mathematics and physics are desirable and may be required for advanced training and advancement in some specialties.

About 400,000 people worked as machinists in 1978. They need to know the characteristics of the materials with which they work, so they can fulfill the specifications or blueprints for their products. Because precision, often to 1/300th the thickness of a human hair, is required, machinists must be adept in making necessary physical measurements.

Related Activities:

Boy Scouts of America. Metals Engineering. North Brunswick, New York: Author, 08902, 1972.

This merit badge pamphlet describes careers in metallurgy, provides information about metals and their uses, and outlines many activities.

Heating and Cooling. Published by McGraw-Hill Book Company, 1221 Avenue of the Americas, New York, New York 10020.

Suggests several different investigations of how heat affects metals.

Weiss, Malcolm E. Why Glass Breaks, Rubber Bends, and Glue Sticks: How Everyday Materials Work. New York: Harcourt Brace Jovanovich, 1977.

Absolutely fascinating account of exactly what the title suggests. For more advanced early adolescents or as a teacher resource.

About Women and Materials Science: (For the teacher)

Sayre, Anne. Rosalind Franklin and DNA. New York: W. W. Norton, 1975.

The controversy over Rosalind Franklin's part in Watson's and Crick's elucidation of DNA's structure has grown heated at times. Sayre's book not only presents the case supporting Franklin's pivotal contribution to this effort, but also exposes problems faced by women both in scientific research and in the reporting of their work. For a quite different account of Franklin's part in the achievements which won the Nobel Prize for Watson, Crick, and Wilkins (Franklin's boss or colleague, depending on your point of view) read Watson, James D., The Double Helix, New York: New American Library, 1969. Ann Kammer (in Science, Sex, and Society, Newton, Massachusetts: Education Development Center, 55 Chapel Street, 1980) has written a most interesting piece about this controversy, weaving together material from Sayre, Watson, and others in a most enlightening fashion.

COMETS Profiles:

Margaret Drake: Mechanical Engineer, Donna Geisler: Engineer, Geneva Hammaker: Chemist, Mary McGhee: Sanitary Engineer, and Marylee Southard: Chemical Engineer.

Each of these profiles provides a look at engineering and related careers.

For More Career Information Write:

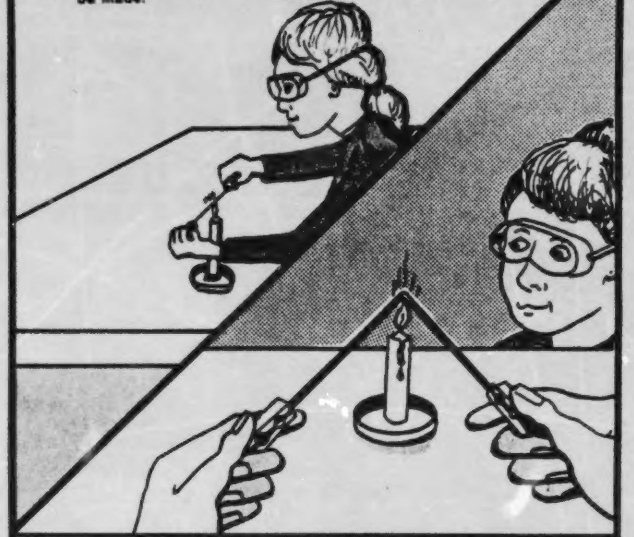
American Ceramic Society, 65 Ceramic Drive, Columbus, Ohio 43214.

American Society of Metals, Metals Park, Ohio 44073.

Metallurgical Society of AIME, 345 East 47th Street, New York, New York 10017. (AIME stands for American Institute of Mining, Metallurgical, and Petroleum Engineers.)

COMETS Challenge Card

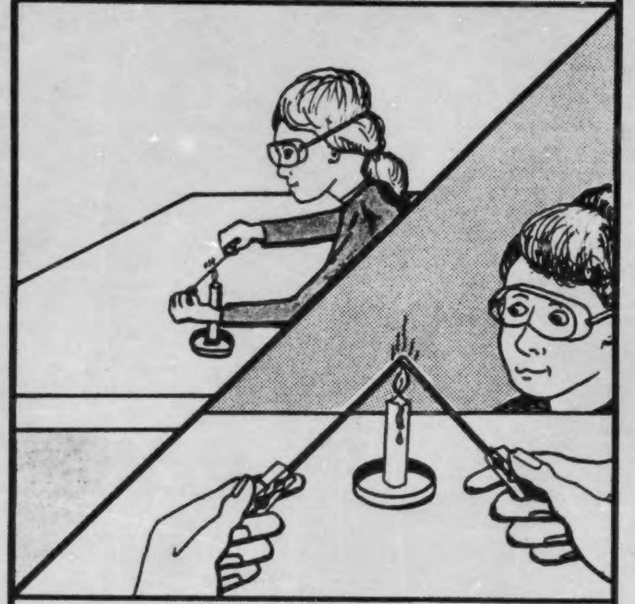
1. Hold a piece of metal wire between two spring clothespins.
2. Heat the center portion of the wire until a 90° bend can be made.



Misc. Materials

Is the bendability of all metal wires the same?

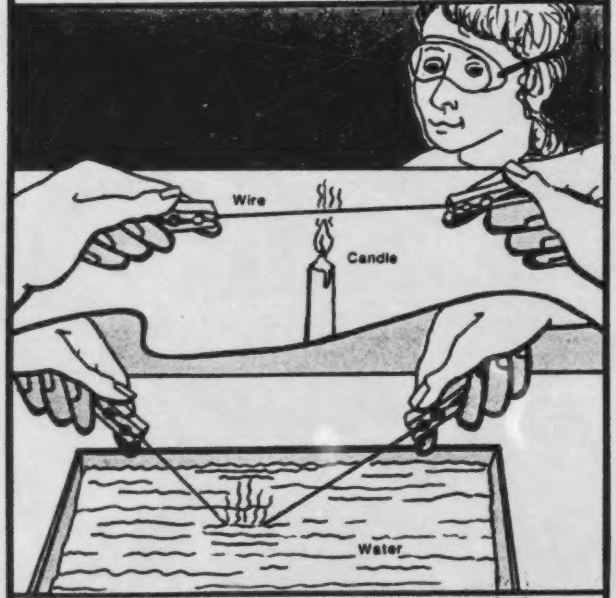
COMETS Challenge Card



Misc. Materials

Is the bendability of different forms of the same metal the same?

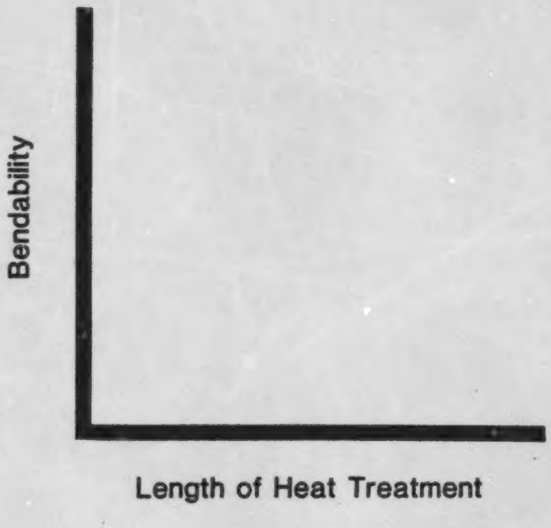
COMETS Challenge Card



Misc. Materials

How does heat affect the bendability of metals?

COMETS Challenge Card



Misc. Materials

How does the length of heat treatment affect bendability?

Career Oriented Modules to Explore Topics in Science

COMETS

TOPICS

Chemistry

Properties of Matter

Recycling

PRODUCT IMPROVEMENT

RESOURCE PEOPLE

Chemist

Engineer, esp. chemical

THIS MODULE

Activity I

"Glurch," a colloidial product of starch, glue, and salt, fascinates with its amazing properties. Fits well in unit on chemistry or when studying properties of matter. Students make Glurch according to various specifications (e.g., make it bounce). Chemists or engineers, especially in chemical field, make good resource persons, who can be used in variety of ways. Quite variable in time, but no less than 20 minutes. Simple equipment. Potential extension activity in economics education. Work of Désiree LeBeau in synthetic rubber or Martha Thomas in phosphors can be related (see "Women and Product Improvement").

Activity II

"Starch Squeeze" provides a brief, interest captivating activity for resource person, especially chemist or chemical engineer. Relates well to unit on chemistry or properties of matter. Little equipment needed. Could be done in five minutes. Could be followed by "Glurch" to allow more systematic study of properties. Work of Thomas and LeBeau can be related.

Activity III

"Paper Production" could be done in unit on recycling, environmental studies, properties of matter, or chemistry. Emphasis is on studying the production process, allowing especially good chance to relate work of Lillian Gilbreth (Cheaper by the Dozen) in "scientific management." Resource people involved in recycling would be especially appropriate, but could use anyone, especially chemical or industrial engineer, involved in making a product. Simple equipment. Variable in time, but no less than 30 minutes.

University of Kansas School of Education Department of Curriculum and Instruction

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RELATED MODULES

Product Improvement is primarily intended for chemical engineers, chemists, or anyone involved in manufacturing, chemicals, food, or other companies making a product.

Body Detectives

Students use red cabbage juice to study acidity of common household products and relate this to the work of medical technologists and similar people who investigate the conditions of the human body. This same red cabbage juice indicator, an amazing substance that turns green, blue, pink, or purple depending on the acidity of what's added to it, can be used by any chemist or other person who tests products. For instance, chemists in the dairy industry constantly test their products for properties such as acidity or bacterial content.

Find Some Evidence

The tests which students do to identify an unknown powder is similar to the analyses done by chemists in industries such as chemicals, petroleum, and so forth.

Misc. Materials

Students test the effect of heat on metals and ceramics. Intended for career people such as metallurgists working with these products.

Electrically Speaking

Resource people, such as electrical engineers who work with power companies, electronics, and related areas, may want to use these activities which deal primarily with basic circuitry and production of electricity.

Pharmacy

Chemists or others who use chemistry may want to have students investigate chemicals, using Pharmacy's activity of testing antacids, antiseptics, and other drugs.

Household Science

Students investigate dyes or make a synthetic material (rayon) as an introduction to textiles.

WHERE TO FIND RESOURCE PEOPLE

Go to an industry in your community where products are being made. Fertilizer, paints, plastics, paper, food, rubber, pharmaceuticals, textiles, petroleum.....the list goes on. Potential resource people work in several parts of an industry. People in a lab test the product. Some work in research and development to improve current products or devise new ones. Others plan, construct, and/or supervise the facility where the product is made.

The local Chamber of Commerce may help you find an industry and put you in touch with a contact person. A local chapter of the American Chemical Society or professional engineering group may provide resource people. The chemistry or engineering department of a college or university employs faculty and enrolls students who are potential resource people.

H.

WOMEN AND PRODUCT IMPROVEMENT

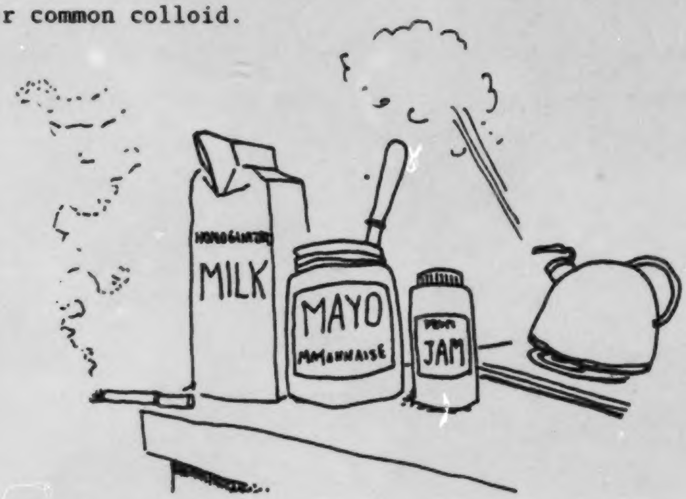
- Fluorescent lights made objects look funny. How could the bulbs be altered to emit a more natural light?
- America's major natural rubber supply was cut off in the Second World War; yet rubber products were essential. How could scrap rubber be used as a replacement?
- Bricklayers were wasting time (and money) when laying bricks. How could their unnecessary motions be eliminated and the whole process streamlined in order to reduce waste?

These questions represent the sort of problems addressed daily by engineers, chemists, and other product improvers; and each of these problems was solved by a woman who applied scientific principles in her career.

Although trained as a chemist, Martha Thomas developed skills as an engineer and became head of the phosphor development work for Sylvania, a major electric product manufacturer. Phosphors are chemicals which receive energy and transmit light. For example, the inside surface of a television screen is coated with a phosphor which when bombarded by electrons is induced to emit light, thus forming the TV image which we watch. Martha Thomas addressed the need for more natural light from fluorescent bulbs, which were efficient energy users, consuming nearly five times less energy than incandescent bulbs and lasting much longer. Unfortunately, these efficient energy users produced light which imparted an unnatural color to fabrics, people, or any other object touched by the light. Fluorescent bulbs were slow to be accepted or were even quite inappropriate for some uses because they made things look "weird." While obtaining seven patents in the phosphor field, Martha Thomas developed a natural white fluorescent bulb which gave more expected, daylight values to colored materials. For her work with phosphors, this mother of four daughters received the 1965 Society of Women Engineers Achievement Award.

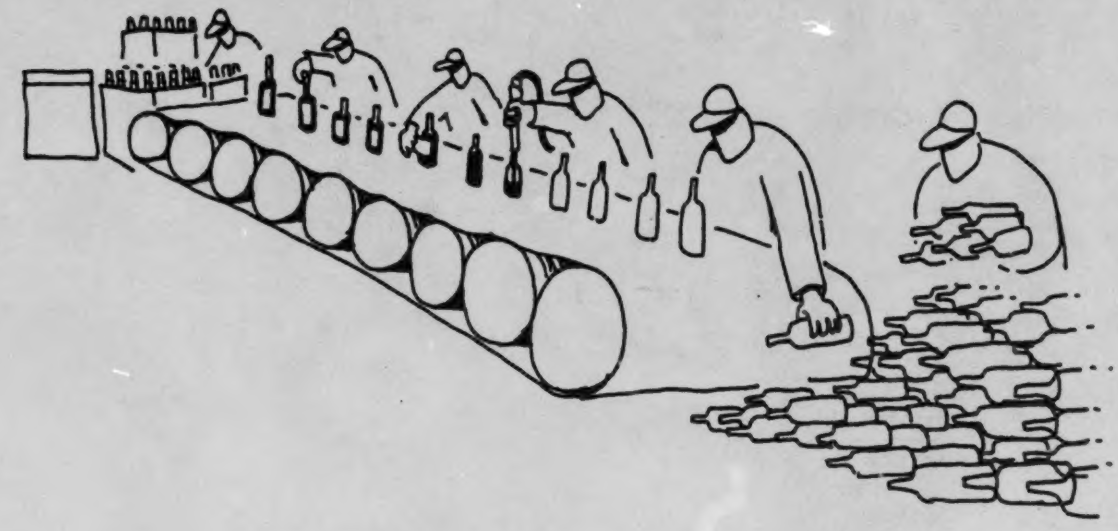
Another winner of an SWE Achievement Award, Désiree LeBeau, a specialist in colloid chemistry, researched and developed several uses for scrap rubber. Her work gained crucial national significance in World War II when America's primary rubber source fell into enemy hands and she was selected by Midwest Rubber, the world's largest independent reclaiming company, to head its research department and to study synthesis processes for this desparately needed commodity.

Colloids, Dr. LeBeau's speciality, embrace many interesting materials ranging from meringue to smoke, and protoplasm to mayonnaise, all of which have in common one material suspended within a second material. The first material, because it exists as extremely small particles, each composed of only a few molecules clumped together, is held suspended in the second material and doesn't settle out. Remember an eerie, grey day when teeny droplets of water floated suspended in the air. The presence of the water droplets could be felt, but they were not large enough to fall as rain. That fog was a colloid of water suspended in air. Homogenized milk, formed when cream is broken into tiny droplets that can float within the watery portion of milk, is another common colloid.



In the first activity, when your students make Glurch, a colloid, relate to them Désiree LeBeau's work to produce another colloid, synthetic rubber.

While Thomas and LeBeau worked primarily with ingredients and how they could be put together in different ways and combinations, Lillian Gilbreth was more interested in studying the production process itself. Lillian Gilbreth and her husband, Frank, pioneered efficiency engineering. They wrote Brick Laying System after having noticed that no two bricklayers used the same set of motions to lay bricks. "Surely there must be one best way to do that," they thought; and their studies led to techniques which improved the bricklayers' efficiency. As a result of this increased production, they were able to pay their own bricklayers higher wages than other construction firms.



With this beginning, Lillian Gilbreth continued to study what was called "scientific management," which has led to the modern study of management and systems. One of her particular interests, as the mother of twelve, was making improvements in the home's efficiency. This interest and series of experiments at home became the basis of the book, Cheaper by the Dozen, a delightful story written by two of her children and retold as the classic movie, Life With Father. After her husband's death, Lillian Gilbreth served as a consultant to manufacturers whose products were sold worldwide; and at the start of the Great Depression she headed President Hoover's Emergency Committee for Employment.

Her work can be related by you or your resource person to any of the three activities in this module. Point out to students how they are carrying out a process to make a product. They can vary the type and/or the amount of ingredients; and/or they can vary the production process. In these alterations they are working with the chemistry of the materials in order to improve the product. However, without altering the ingredients or the basic production process, they can study and improve on how they carry out the process. In this case they're not improving the product. Rather, they are improving the process for making the same product. For example, they might make two batches of Glurch simultaneously by stirring with both hands, thus doubling their Glurch output per unit of time. If they were getting paid for their output, then they would get twice as much money for their work. This is the kind of concern and expertise Lillian Gilbreth brought to engineering.

Activity I: Globs O' Glurch

Materials:

- Table salt (½ teaspoon/batch of Glurch).
- Liquid laundry starch (½ cup/batch).
- White glue, such as Elmer's Glue® (¼ cup/batch).
- Containers, such as half of styrofoam sandwich container from fast food restaurant.
- Stirrers, such as popsicle stick.
- Newspaper.
- Running water (to wash hands!).

Recipe for Glurch:

Working over newspaper, stir ½ teaspoon salt into ½ cup liquid starch in container. Add ¼ cup glue and stir 30 or more beats. As the colloidial Glurch begins to coalesce, roll up sleeves and begin to knead it, squeezing out excess liquid, until it becomes doughy. If the Glurch remains runny, add salt sparingly. Be patient.

Procedure:

Have students make their own Glurch and then observe the following properties, comparing their Glurch with the original materials and with each other's Glurch.

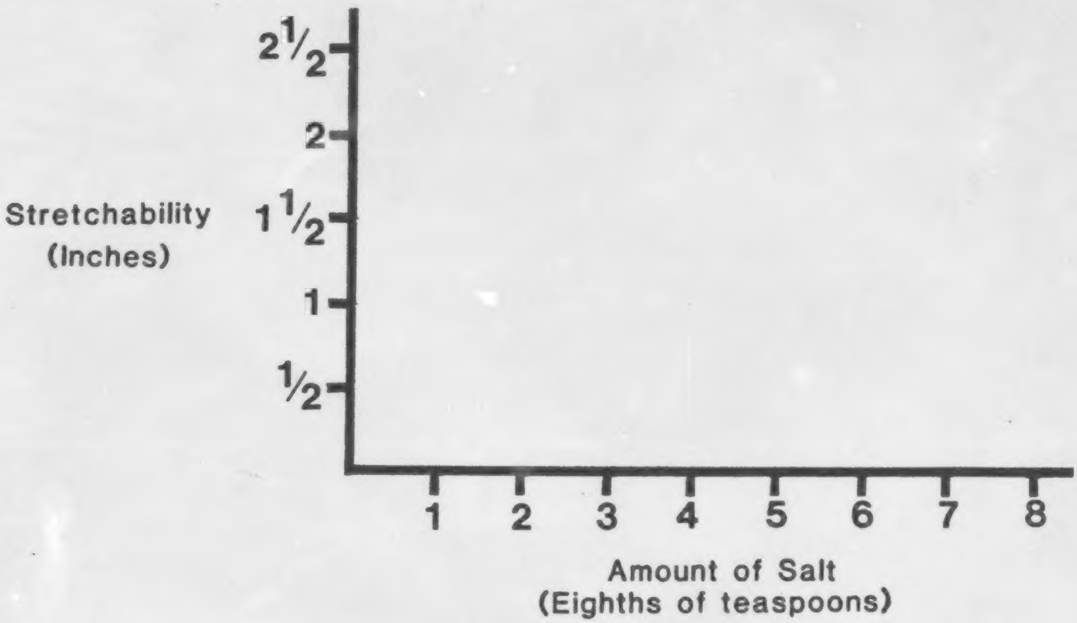
- How does it feel?
- Will it bounce? (Caution: Some Glurch may stick to some surfaces. Put down newspaper before bouncing Glurch.)
- Pinch Glurch between thumb and forefinger. How well does it flow?
- How long can it stretch before breaking?
- Does it pick up newsprint?
- Can it be used to stick two pieces of paper together?
- How well is Glurch absorbed into an old rag?
- What happens to Glurch left out overnight? Can it be returned to its previous state?

After students have observed their Glurch for awhile, ask them to consider whether Glurch has any advantages or disadvantages over the original ingredients? Is Glurch liquid or solid? (There's no simple answer to this question. Being a colloid, it has properties of both liquids and solids. Depending on the makeup of any particular batch of Glurch, the liquid or the solid properties may predominate.)

At this point you may want to tell them about colloids. Describe their characteristics, mention examples, and relate to them the story of Désiree LeBeau's work with synthetic rubber.

Extension Activity I: Quantifying Glurch

To this point in the lesson the students have been "messing around," finding out what they could about this novel material. In a sense they have been doing basic research. Now ask them to assume they have been hired as a chemist or engineer to make Glurch according to certain specifications; they must become applied researchers, using many of the skills of an engineer in product development. To meet these challenges, they should study Glurch in a more systematic way. For example, they could vary the amount of salt and/or when they added salt to see how these changes affected Glurch's ability to flow, or bounce, or be stretched. They could graph their results to see whether Glurch varies in any systematic way as the salt content is varied.



Present these challenges to students or duplicate and hand out the Product Improvement Challenge Cards which involve these same specifications.

- Make two Glurches, one that bounces three inches and another that bounces only ½ inch when dropped from three feet.
- Make two Glurches, one that flows twice as fast as the other when held pinched between finger and thumb.
- Make two Glurches, one that tears and one that stretches when pulled apart.
- Make two Glurches, one that's smooth and one that's lumpy.
- Make Glurch to some specification(s) you or another student dream up.

Here are some hints on how to alter Glurch to meet these aforementioned challenges.

- Change proportions of ingredients.
- Delete an ingredient or add something new (e.g., flour).
- Substitute a new ingredient for an old (e.g., rubber cement for glue, starch powder for liquid starch).
- Change the production procedures in some way such as:
    - stirring or kneading different lengths of time.
    - kneading the Glurch inside or outside the pool of excess starch.
    - changing sequence in which ingredients are added.
    - extending the production process by heating or cooling or simply allowing Glurch to sit undisturbed.

Using the Resource Person

The resource person could be involved in this activity in any of several ways, so it is particularly important to discuss their degree and type of involvement ahead of time.

Since completion of this activity and its extensions span several days and in fact could be very open-ended, the resource person could wait to talk with students after the activity has been largely completed under the teacher's direction. In this case, the resource person could point out the parallel between producing Glurch to certain specifications and the way they make some product to meet certain specifications. The work of Martha Thomas to improve fluorescent lights could be related as an example of product improvement.

Alternatively, the resource person could have students make a batch of Glurch and do some of the initial investigations of Glurch's properties with students. While this is a highly fascinating activity, certain to capture almost all students' interest, it does take minimally 20 minutes and usually more like 30-40 minutes. Thus, the time would be quite limited for the resource person to draw a parallel to their career and then talk about their career.

As a third alternative, the teacher could start the activity and the resource person could visit after the initial investigation has been completed. The resource person could then point out that product improvement involves some general investigation, as the students had already done, but that more specific and detailed experimentation would be necessary to make a useful product. After talking with students about their career, the resource person could leave the Challenge Cards, asking the students to make Glurch according to one of the specifications in Extension Activity 1.

Extension Activity 2 : Economic Glurch

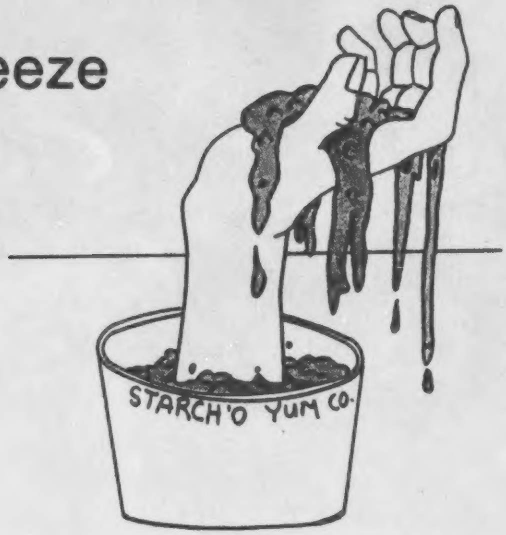
While Glurch's ingredients are relatively inexpensive, the cost begins to mount when multiple batches are made. You may want to recoup some of your costs by going into production and selling Glurch in the school. This would be an excellent basis for a lesson in economics, involving cost estimating, financing the production, mass producing, marketing, and so forth.

Involve your students in setting up a company, Glurch Limited, to carry out this activity, which can be as simple or as involved as you and your students desire. For more information about this type of economics education activity, write Joint Council on Economic Education, 1212 Avenue of the Americas, New York, NY 10036 or call 212/582-5150. They can refer you to your nearest council or center for assistance.

Relate how Lillian Gilbreth (see "Women and Produce Improvement") was one of the early practitioners of "scientific management" and developed procedures for making production more efficient just as the students will have to do in order for Glurch Limited to be successful. Students may want to read the book, Cheaper by the Dozen, and look for parallels in their own situation.

(Caution: Glurch has one additional use; it makes wonderful spitwads. Consider this possibility prior to mass producing Glurch. Perhaps you'd want to make paper instead. See Activity III, "Paper Production," for how to make recycled paper.)

Activity II: Starch Squeeze


STARCH'O YUM CO.

Materials:

- Cooking starch (½ cup/batch).
- Water.
- Newspaper.
- Mixing container, such as half of styrofoam, fast food sandwich box.

Procedure:

The resource person who desires a brief activity could introduce their visit with this activity. The activity can be made even more brief by having a volunteer student make one batch of paste and then carry out some of the observations as a class demonstration.

Mix ½ cup powdered cooking starch with enough water to make a smooth paste. Pick up a handful of this paste and squeeze it dry.

- What effect does squeezing have on the paste?
- Does squeezed paste flow? Does unsqueezed paste flow?
- What happens to squeezed or unsqueezed paste if you strike it?
- What happens to the squeezed paste, if you let it sit undisturbed? When the paste sits, it "relaxes" and becomes runny. The paste can be changed from hardened to relaxed by alternately squeezing and resting it.
- How often can the paste be changed back and forth?
- Does any property of the paste systematically change each time it is squeezed? (For example, is it harder, or more crumbly after each succeeding squeeze?)

This activity has the advantages of brevity and fascination. However, the resource person (or the teacher) will need to make a verbal bridge from this activity to the engineer's or chemist's career tasks in product improvement. The engineer or chemist resource person should point out that they too study and apply observations of some material, just as the students had observed the runny starch. The resource person could then go on to describe their own product, bring in an example to show students if at all possible, and then talk about their own career.

Activity III: Paper Production

Materials:

- Old newspapers.
- Window screen (use scrap pieces about 6" x 6").
- Hand or electric mixer.
- Pan (such as small plastic dishpan).

100% Recycled Paper

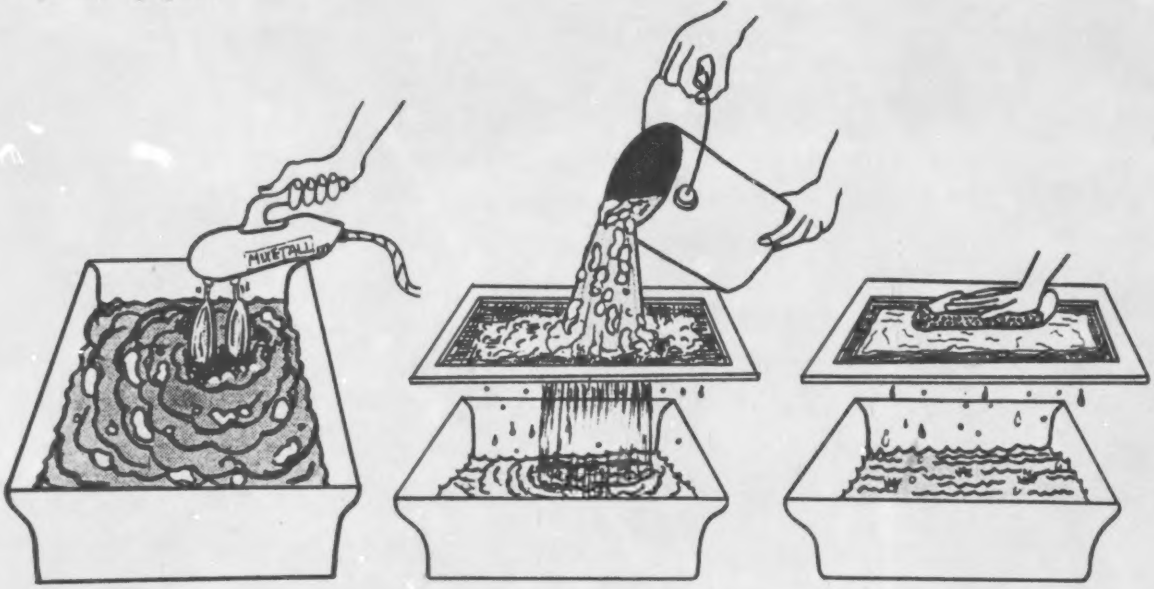
Procedure to Make Recycled Paper:

Shred newspaper into small pieces (like confetti) in pan of water. Mix thoroughly by hand or electric mixer until the soaked paper has become a pulp. The smaller the particles, the better quality paper you will produce. (You may want to "wash" the pulp by repeatedly straining out the dirty water in which the ink has dissolved.)

Pour the pulp through the screen, allowing as much water to drain through as possible. You may want to get fancy by enclosing the screen in a wooden frame with scrap lumber. Such a frame will make it easier for you to make a nice product with straight edges and square corners.

Gingerly press on the pulp to force more water through the screen. More water can be removed with a sponge or paper towel.

Place the drying pulp between layers of paper. Press overnight between heavy objects; or dry the pulp with an iron. The dried pulp will be "recycled" paper.



Using the Resource Person

As in the Glurch activity, the resource person can be used in a variety of ways, either at the start of the activity or after its completion by students.

Students can be challenged to improve their paper in any of the following ways:

- Make cleaner paper to use as stationery.
- Make coarser paper that might be used as packing material.
- Make wrapping paper. (Food coloring might be added to the pulp.)
- Make paper of uniform thickness.

Students can investigate various parts of their production process.

- Does making the original confetti smaller help? What is the tradeoff in time and effort between quickly making large confetti and taking time to make the confetti pieces smaller?
- How much energy is used? What is the tradeoff between pressing the paper overnight and drying it with an iron?
- What special equipment is needed to make a finer quality paper, such as something that could be used as stationery, versus a more cardboard like paper that could be used as packing? Besides equipment, what else adds to the cost of the finer paper?

Resource people who work with recycling might particularly find this activity applicable to their own careers.

The activity focuses almost entirely on studying the production process; thus engineers, especially industrial or chemical engineers who work on making products, could relate to this activity. You or your resource person should tell students about Lillian Gilbreth and her contribution to studies of management and efficiency. (See "Women and Product Improvement".)

Career Information–Engineering

With the exception of teaching, more Americans are engaged in engineering than any other profession. Historically, women have represented less than one half of one percent of engineers; but as of 1978 approximately 2% of America's 1.1 million engineers were women, and 9% of the 1979 graduating engineers were women. Almost 14% of that year's college freshmen were women, and at some schools nearly half of the engineering students are women; so this once nearly totally male domain is being practiced by both sexes. Some temporary economic exigencies have led to sensational headlines of "engineers out of work" and have resulted in declines in engineering enrollments. Such employment setbacks, while real to the people involved, really should be thought of as blips on the employment curve. Engineers are generally sought after by employers and thus have enjoyed an enviable position in the marketplace.

All engineers possess some degree of interest and ability in science and its technological applications, but the career of engineering is marked by a great diversity in the way and setting in which it is practiced. Some engineers spend a great deal of time outdoors; others work at their desks. Most work in an indoor setting. Some focus on a narrow problem; others are jacks-of-all-trades, so to speak. Some come in daily contact with many people; others have relatively few interpersonal contacts. Some work "9 to 5" and close to home; others travel and/or have a variable schedule. Some are their own bosses; others work in large teams.

Just as their job conditions vary, their job tasks may be one or a combination of many. Some engineers design structures (e.g., a new assembly line or bridge) or a product (e.g., a pocket calculator or a bathtub); others supervise construction of a structure or production of a product. Some work in planning (e.g., selecting the right equipment to manufacture a typewriter); others work in testing to ensure product quality. Some work in engineering education (a field currently in increasing demand); others work in research, focusing on devising new techniques on the edge of basic research and/or on research applications (e.g., taking space age developments and applying them to everyday life, as when nonstick substances were developed for the space program and then used in cooking utensils). Some work in sales; others work in servicing customers.

Engineers generally specialize during their training according to the type of product with which they plan to primarily work. While these categories overlap, engineers usually are designated as civil (work with large structures such as bridges), mechanical (work with machinery), mining or metallurgical, chemical, electrical, or a host of subcategories (e.g., nuclear, agricultural, environmental, or ceramic).

Regardless of their eventual field of specialization, students considering engineering should study as much math, science, and English as possible in high school. (Yes, engineers must communicate as well as apply math and science.) Whether or not they eventually enter engineering, these courses will allow, but not force, such a choice; and their high school will have provided a solid foundation for many careers.

Career Information–Chemist

Much of the preceding information about engineering also applies to careers in chemistry. Chemists work as researchers (both basic and applied), teachers, consultants, quality controllers, or salespeople. Some apply their chemistry knowledge to library work, helping researchers, and others ferret out needed information from the deluge that's available. Many technical careers, requiring less than four years of undergraduate training, apply chemical knowledge to production and testing.

Quite frankly, chemistry has had a bad reputation among some who think it "stinks." Hydrogen sulfide's rotting egg odor, and the other aromas of the chemical lab or plant, color many people's thoughts. Others have a picture of the "mad scientist," too often reinforced by the image portrayed on TV. While these images cannot be brushed off as totally unfounded, they do not in any way adequately picture the life of chemists. Your resource person should address and dispell these images.

Chemists work in a variety of industries. Of course, organizations such as DuPont, Union Carbide, Monsanto, and Dow -- the large chemical producers-- employ many chemists for a variety of jobs. However, chemists are also found in foods, metals, petroleum, building materials, soaps, or any other production industry.

If students are "turned on" by activities such as Glurch (in this module) or Red Cabbage Juice (in *Body Detectives*), they may very well enjoy further study in chemistry. Encourage them to enroll in high school science and mathematics, the undergirding subject areas for careers in this area.

Related Activities:

Cobb, Vicki. *Science Experiments You Can Eat*. New York: J.B. Lippincott. 1972.

Shalit, Nathan. *Cup and Saucer Chemistry*. New York: Grosset and Dunlap. 1972.

Fegely, Thomas. *Recycling*. Emmaus, Pennsylvania: Rodale Press. 1973.

COMETS Profiles:

Marylee Southard: Chemical Engineer.
This Profile highlights the training and work of a young engineer for a producer of a variety of chemical products.

Geneva Hammaker: Chemist.
Dr. Hammaker's varied life as parent, spouse, teacher, and researcher is portrayed.

For More Career Information Write:

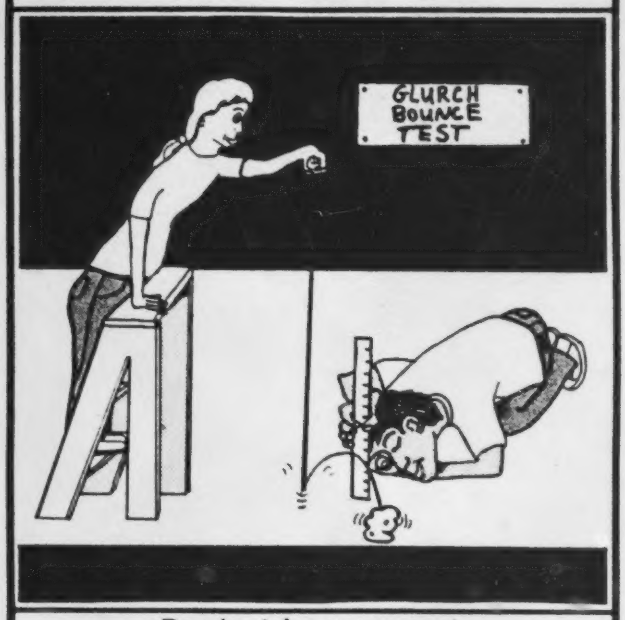
Engineers' Council for Professional Development, 345 E. 47th Street, New York, N.Y. 10017. An umbrella organization composed of several engineering societies.

Society of Women Engineers, 345 E. 47th Street, New York, N.Y. 10017.

American Chemical Society, 1155 16th Street, N.W., Washington, D.C. 20036.

Your state's public or private schools of engineering.

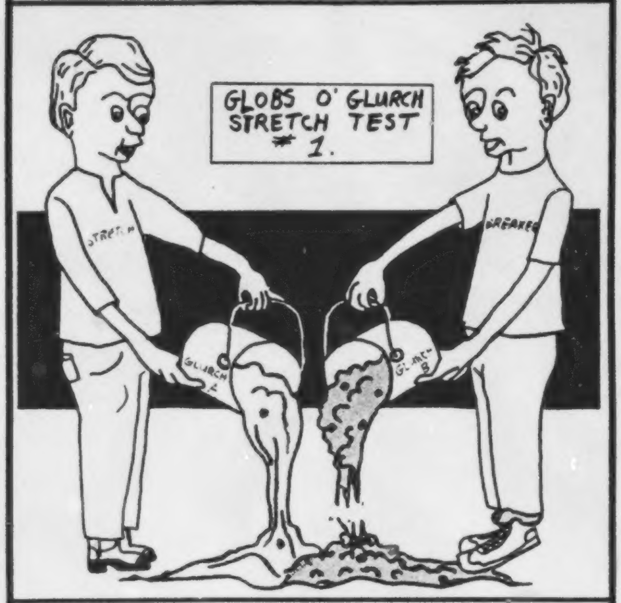
COMETS Challenge Card


GLURCH BOUNCE TEST

Product Improvement

Make Glurch that will bounce three inches when dropped three feet.

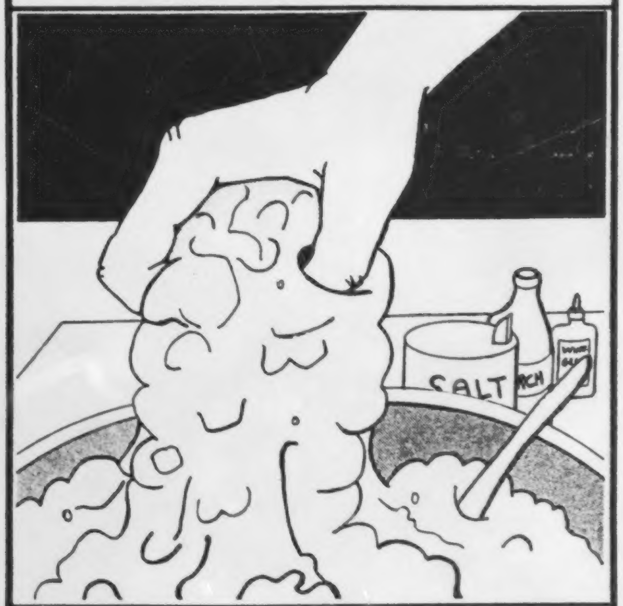
COMETS Challenge Card


GLOBS O' GLURCH STRETCH TEST # 1.
STRETCH
BREAKER

Product Improvement

Make a Glurch that stretches and one that breaks when poured to the floor.

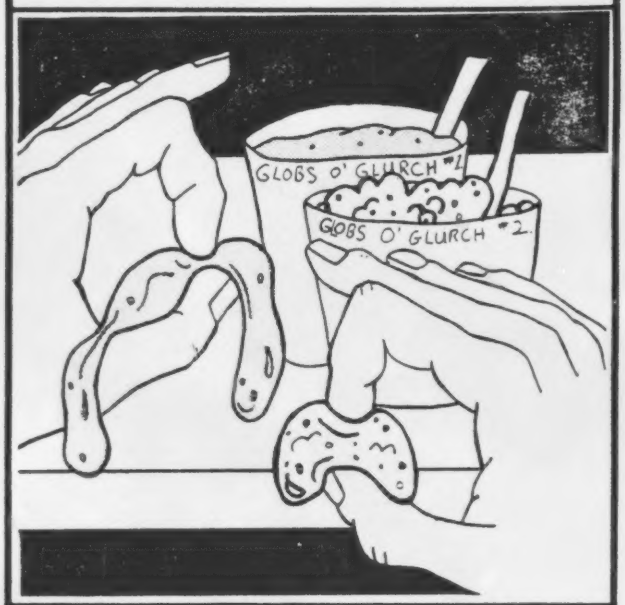
COMETS Challenge Card



Product Improvement

Make lumpy Glurch.

COMETS Challenge Card


GLOBS O' GLURCH #1
GLOBS O' GLURCH #2

Product Improvement

Make two Glurches, one that flows twice as fast as the other when pinched between two fingers.

Career Oriented Modules to Explore Topics in Science

COMETS

TOPICS

- Geology
- Ecology
- Experimentation

Soil

RESOURCE PEOPLE

- Geologist
- Farmer
- Land Use Planner

THIS MODULE

Activity I

In the "Perc Test" students do a laboratory test of soil permeability and porosity, and then they test permeability in the field. Both activities take some time, so they should probably precede and/or succeed the resource person's visit. Required equipment is simple, but must be handmade by the teacher or preferably by the students. The work of Eileen Kladivko (see "Women and Soil") can be related to this activity. In all activities in this module students can practice process skills associated with experimentation.

Activity II

"Making Dirt" demonstrates the natural recycling process by which organic material is decomposed and returned to the soil. Thus it could be used in units on soil, geology, or ecology. Both activities require simple equipment. The first activity's materials must age at least overnight prior to the resource person's visit; but relating the activity's career applications could be done briefly. The second activity takes at least two months to allow for decomposition.

Activity III

The first activity in "What's In Dirt" briefly demonstrates how soil particles are sorted by water. Only a jar, dirt, and water are needed. For the second activity a Berlese Funnel must be made (directions include using fairly common materials) and used to inventory animals living in the soil. Comparisons can be made among soils of differing compositions and from varying locations.

University of Kansas School of Education Department of Curriculum and Instruction

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RELATED MODULES

Soil is intended for geologists, soil scientists, land use planners, farmers, extension agents, building contractors, civil engineers, and others who work with soils. They might also teach an activity from one of these modules.

Fluid Follies

Students use stream tables and other simple apparatus to study characteristics of fluids and life in a stream.

Third Dimension

Using both two and three dimensional apparatus, students learn to interpret and visualize objects in space.

Outdoor People

Various ecology concepts such as the effect of temperature on behavior are studied.

Chances Are

This module teaches the general concept of sampling in order to make predictions about the general population as is done in Soil, especially in Activity III's inventorying of soil animals.

WHERE TO FIND RESOURCE PEOPLE

Soil scientists can be contacted through the area's soil conservation service office. Look under federal government in the yellow pages, or ask for a reference from the county agricultural extension agent, who would also make a good resource person. Many farmers, especially those with vocational and/or collegiate training in soil, could be used with these activities. References could be obtained from an agriculture extension or farm bureau office, or from a farm co-op, grain elevator, or similar business. Contact the local or regional governmental land use planning office. Other governmental agencies dealing with soil are the U.S. or state geological survey, Bureau of Indian Affairs, environmental protection agencies, forestry office, and agricultural experimental farms. Construction companies, builders, and consulting firms employ civil engineers, many of whom work with soil. Landscape architects could also be resource people and be contacted through nurseries. Contact a university geology, civil engineering, agronomy, or agriculture department.

Women and Soil

Sewage sludge is rich in organic content and would appear to be a good additive to rejuvenate soil. But is it? Just what does sludge do to the physical and biological properties of soil? Is sludge equally good on all soils? How should the soil be tilled, if at all, after the sludge has been added? Just what kind of a process does sludge go through as it decomposes? These are questions of interest in a country becoming more keenly aware of (1) agriculture's importance to the national economy and (2) the need to recycle natural materials. And it's these kinds of questions which interest the young soil scientist, Dr. Eileen Kladivko, a Purdue University faculty member in applied soil physics.

The availability of essential nitrogen for plant growth depends on a host of soil microorganisms. Nitrogen is a very plentiful material in our environment; after all, about 80% of air is nitrogen; but free nitrogen cannot generally be used by plants. Each of a series of soil bacteria take dead plants and animals and wastes and produce ammonium (NH_4) compounds, which in turn are changed to nitrites (NO_2), which in their turn are changed to nitrates (NO_3), which in turn can be used by green plants.

Thus, the availability of key soil bacteria is crucial to this nitrogen cycle. However, these bacteria are affected by soil temperature, water availability, degree of soil aeration, mixing of plant and animal material into the soil, breakup of the soil during tillage, and so forth - all physical properties of soil and within the preview of Kladivko's interests. According to Kladivko, microbial activity in the soil is related to water content. When soil is too dry, the bacteria's action is slowed due to the lack of water; but when the soil is too wet, bacteria activity is also diminished, this time due to lack of air. Thus, tillage procedures must be modified to make certain just the right amount of water is in the soil.

But what about sludge treatment of soil? Kladivko found that adding sludge to the soil surface reduced the loss of soil through erosion. It appears that the sludge acts like a kind of umbrella, shielding the underlying soil from some of rain's direct impact. In addition, the sludge acted like a glue, helping the soil particles stick together. Of course, the best rate of sludge application must be determined, for too much sludge could turn the umbrella into a blanket which would keep water from the soil and the glued together soil could become clotted clumps impervious to water. And the best tillage procedure must be determined, because sludge on the surface can have its umbrella effect, but it must be incorporated into the soil to do it gluing job and to be available to the soil bacteria in the nitrogen cycle. And on it goes. As Kladivko and other soil scientists study sludge application, the use of this rich source of organic material is becoming better understood.

During the teaching of any of this module's activities, the work of Dr. Eileen Kladivko with the physical properties of soil can be mentioned.

Activity I: Perc Test 1234

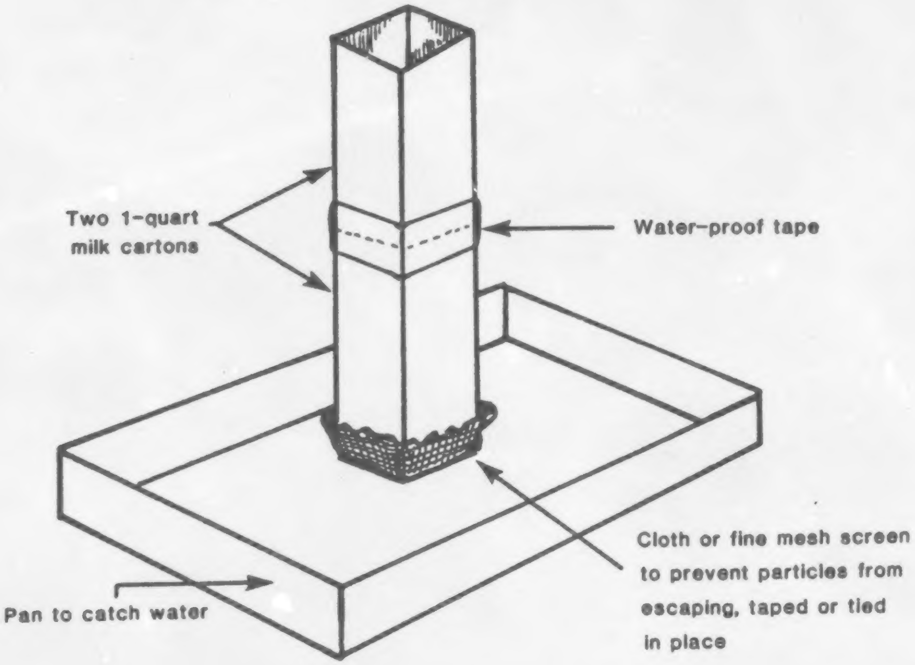
Materials:

- Two one quart milk cartons with tops and bottoms removed and cartons taped together as in the illustration.
- Cloth or fine mesh screen taped to the bottom of the milk carton column.
- Pan for catching water.
- Three or four types of soil particles, such as fine, medium, and coarse sand, silt, clay, or humus.
- Water and container (e.g., pitcher).
- Graduate cylinder, cup, or some standard-sized container (e.g., one pound coffee can).
- Hand lens.

Procedure:

Ideally each one to three students should have a set of the materials, although the activity could be done as a demonstration. The resource person should describe the perc test which the students should then do for two samples apiece.

All samples tested should be of equal volume (enough to fill the column one-half to three-fourths full). Place the soil in the column without packing.


Two 1-quart milk cartons
Water-proof tape
Pan to catch water
Cloth or fine mesh screen to prevent particles from escaping, taped or tied in place

Be sure that the screen is in place and the soil particle container is firmly held to the bottom of the catch-pan so that water will not seep out. (It may be necessary to secure waterproof wrap over the bottom screened-end of the container to prevent leakage.) Water should be poured into the soil until the soil becomes saturated (i.e., no more water can soak in) and the volume of water recorded. The container should be gently lifted a little above the pan bottom and the plastic wrap, if used, removed. Students should record how long it takes from the first water flow until the major flow stops. (It's not necessary to time to the last drop.) The material should be cleaned, but the soil samples should be kept. Data regarding length of flow can be recorded on the board, averaged for each soil type, and graphed in a histogram (type of soil on the horizontal axis, with soil types shown left to right by decreasing length of flow, and time on the vertical axis). Similarly, data regarding how much water could be held by the soil could be graphed as a histogram (type of soil on horizontal axis, with soil types shown left to right according to decreasing volume of water held, and volume of water held on the vertical axis).

After the data collection, discuss with students some of the following questions.

- With a hand lens look at the particle size in each soil. Is there a relationship between particle size and length of flow? (Permeability is a measure of how fast water can flow through a soil or other material.)
- Is there a relationship between particle size and how much water the soil could hold? (Porosity is a measure of the amount of water that can be held by a soil or other material.)
- Is there a mixture of particle sizes or are all particles in the soil the same size? (Sorting is a measure of how uniform the particle size is within a soil.)
- Is there any relationship between sorting and porosity or permeability?
- Is there any relationship between porosity and permeability?

At this point resource people should comment on how they use the concepts of porosity, permeability, sorting, and/or other soil properties in their work. (They may in addition or as a substitute activity perform soil tests which they use more frequently. For example, some resource people may choose to demonstrate and discuss the significance of soil pH tests.) The work of Eileen Kladivko (see "Women and Soil") can be related to this activity.

Extension Activity 1: Soil Perc Testing

Materials:

- A can (e.g., one pound coffee can or juice can) with both ends removed. The can should be calibrated to measure volume. (One calibration technique is to mark a piece of tape each ¼" with indelible ink. The tape should then be placed vertically inside the can with the smaller numbers at the top. As the can is used, students can record volume of water drained out in terms of ¼" of water. If desired, the ¼" could be changed to cubic inches, using the formula, $V = \pi r^2 h$, where h = ¼" and r is the radius of the can.)

Procedure:

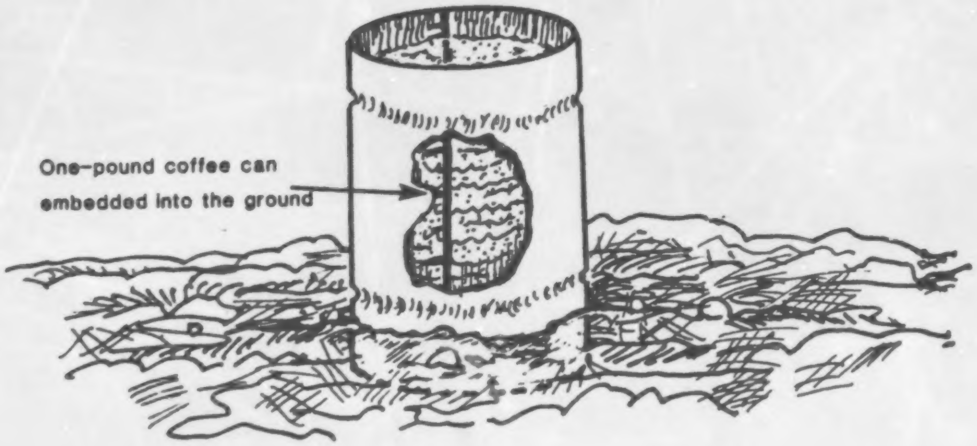
Whereas Activity I is a laboratory test of permeability, this extension activity is a field application of that test. This extension activity could follow the resource person's visit, or it could precede the resource person's visit and be commented on by the resource person.

This activity requires some creative organization of class time, if your classes are scheduled in 45-60 minute periods. One possibility is to start the activity during the day's first period and then have succeeding classes make observations throughout the day. Each class could start their own cans, as well as collect data for other classes, so they all get to do all parts of the activity. Discussion of data could take place the following day. This activity works best in soil free of vegetation and not frozen. The test should be done in at least two different soil types. For example, the test could be done in the middle of a frequently used path (in which case, a "guard" may need to be posted) and in a well tilled garden. Following are directions to be given students.

Embed one end of the can about 1" into the soil with the smaller measurements on the tape up. Fill the can with water. Let this water seep into the ground and repeat until water seems to stop soaking into the ground and stays in the can. Refill the can once more and record the amount of water that soaks into the ground in 15 minute intervals for at least 45 minutes.

After the data have been collected, they can be graphed and these questions can be raised.

- What do the results imply about the permeability of the soil tested?
- Was permeablity constant? That is, did the same amount of water drain into soil in each 15 minute period? (This question provides a good



opportunity to look at the general shape of the graph. If the slope is constant, then the rate of drainage is constant. Students could transform their first graph (time on horizontal axis versus total water drained to that point on the vertical axis) into a second order graph (time on horizontal axis versus water drained in the immediately preceding 15 minute time interval on the vertical axis). If this second graph produces an approximately flat line (i.e., slope approximately zero), then the rate of drainage is a constant.)

- What would happen to rainwater falling on each of these soils? What implications might your answer have for city planning? (Might different neighborhoods have different requirements for handling runoff? Consider asphalt, concrete, and other building materials. How permeable are these materials?
- Does there seem to be any relationship between the amounts, types, and health of plants growing in soils of different permeability?

Extension Activity 2: Soil Slope

Materials:

- One hundred feet of heavy string or light rope with a knot every five feet.
- A second string with a weight at the end.
- Level.
- Yardstick.

Background Information:

The slope of a plot of land is the change in vertical distance divided by the change in horizontal distance between two points. Slope is sometimes referred to as the rise over the run.

$$\text{Slope} = \frac{\text{change in vertical distance}}{\text{change in horizontal distance}} = \frac{\text{rise}}{\text{run}}$$

As an illustration of slope, consider two points on a plot of land. One point is six feet above the second point, and they are 100 feet apart (that's not 100 feet on the ground; it's 100 feet apart measured horizontally between the two points). Thus, the change in the vertical distance between the two points, i.e., the rise, is six feet, and the change in horizontal distance, i.e., the run, is 100 feet. Thus, the slope is 6/100, or .06, or 6%. Compare this slope with the slope of another plot where the rise is two feet and the run is 100 feet. The second slope would be 2/100, or .02, or 2%. The slope of the first plot is three times greater than the slope of the second plot.

To measure slope, have one student hold one end of the 100 feet rope at ground level and the second student hold the other end downhill, taut, and level. A third student can use the level to help make certain the string is level. A fourth student should measure the vertical distance from the second student's end of the string to the ground directly below. This can be done with the yardstick, or the second string could be held next to the second student's end of the string and with the weight touching the ground. The length of this string could then be measured. This vertical distance is the rise and 100 feet is the run. By using 100 feet as the run, the calculation of slope is made easier; but there is nothing magical about a run of 100 feet. In some steeply sloping land, it may be possible only to measure a much shorter run. The long string should be tied off at five feet intervals to facilitate the measurement of shorter runs.

Procedure:

Data can be gathered to determine slope and then this information can be put together with measures of permeability, if available, to get a better idea of water runoff on various plots of ground. Erosion, tillage practices, types of vegetation, and slope can be observed. Resource people should comment on how this information is used in planning land use.

Activity II: Making Dirt

Materials:

- Two glass jars with tight lids (e.g., old one pint salad dressing jar).
- Approximately four quarts of fresh grass clippings.
- Cookie baking pan or similar baking pan.
- Oven (optional).

Preparation:

Spread about a quart of glass clippings on a cookie tray and place in direct sunlight (or in oven at 200°F to speed the process). Thoroughly dry the grass.

Procedure:

This activity should be started 24 or 48 hours prior to the resource person's visit. If desired, this activity could be repeated for as many student groups as there is equipment. However, more repetitions require more materials. Although the activity takes some time, the resource person's involvement is brief.

Pack dry grass clippings in a pint jar and fresh, moist grass clippings in a second pint jar. Have student note odor, temperature, and color of the grass in the two jars and then tightly screw the lids on the jars. They should be observed each 24 hours. Students can put their fingers down into the grass to feel the temperature. (The moist grass will begin to decompose as will be indicated by the odor of fermenting grass and a somewhat elevated temperature. Within days white "cobwebs" of mold may appear. The jars and contents should be thrown away then. The same process may occur in the second jar, depending on how dry the grass was at first, but the decomposition process will be slower.)

The resource person should relate this activity to the continual breakdown of organic materials in the recycling processes in soil production.

Extension Activity 1: Soil in a Bag

Materials:

- Three bags of approximately the same size, one of plastic, one with small holes (e.g., discarded pantyhose), and one with larger holes (e.g., vegetable bag such as those in which potatoes are sometimes sold).
- A mixture of grass clippings, vegetable peelings, apple cores, and other natural organic matter.
- Balance.
- Shovel.

Procedure:

This activity takes a couple months to complete, so it can follow the resource person's visit or be started well ahead of the visit, so the resource person could comment on the outcome. This activity can be done by several groups of students or as a total class activity.

Have students weigh three equal amounts of organic matter and place the organic material in the three bags which should be buried under about 4-6" of soil, with 6" of soil separating each bag. The burial spot should be marked. Two months later dig up the bags and examine and weigh the contents. The bags could be reburied and observed throughout the school year. If several sets of bags are studied, they could be buried in different conditions (e.g., moist versus dry or clay versus humus).

As an extension of this particular activity, students could begin a compost pile, using materials collected from the school cafeteria, grass mowed at school, and any other handy source. As in the main activity, the resource person should comment on the process of soil production demonstrated in this activity.

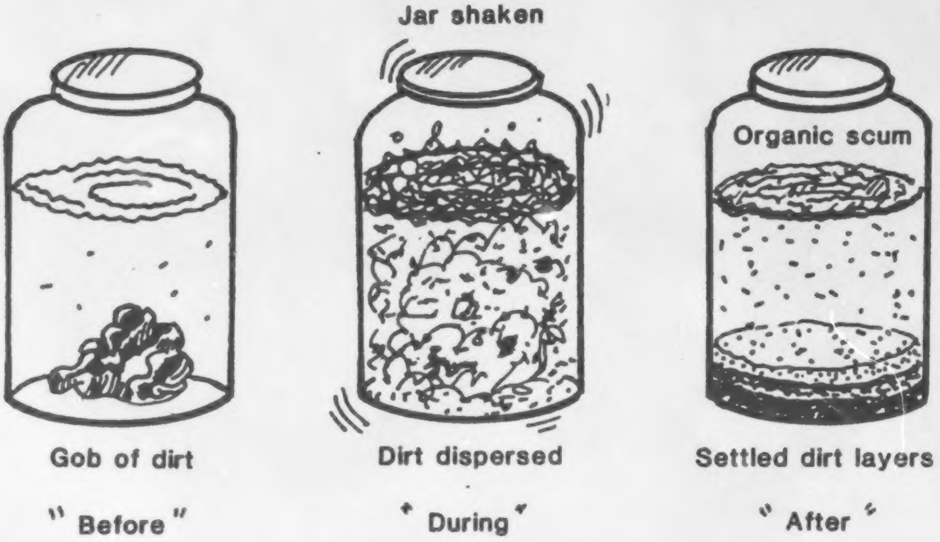
Activity III: What's in Dirt?

Materials:

- Large glass jars with tight fitting lids (e.g., gallon jar from cafeteria).
- Samples of soil (use a soil with a variety of particle sizes, perhaps a sample of humus. If an appropriate soil sample is not available, make a sample that contains a good mixture of particle sizes.)
- Water.
- Scoop.
- Newspaper (to catch mess).

Procedure:

This activity is brief and requires simple materals, so it is particularly appropriate for resource people who desire to do a brief activity and then spend more time talking about their careers. Alternatively, students could do this activity as a follow-up to Activity I to demonstrate sorting.

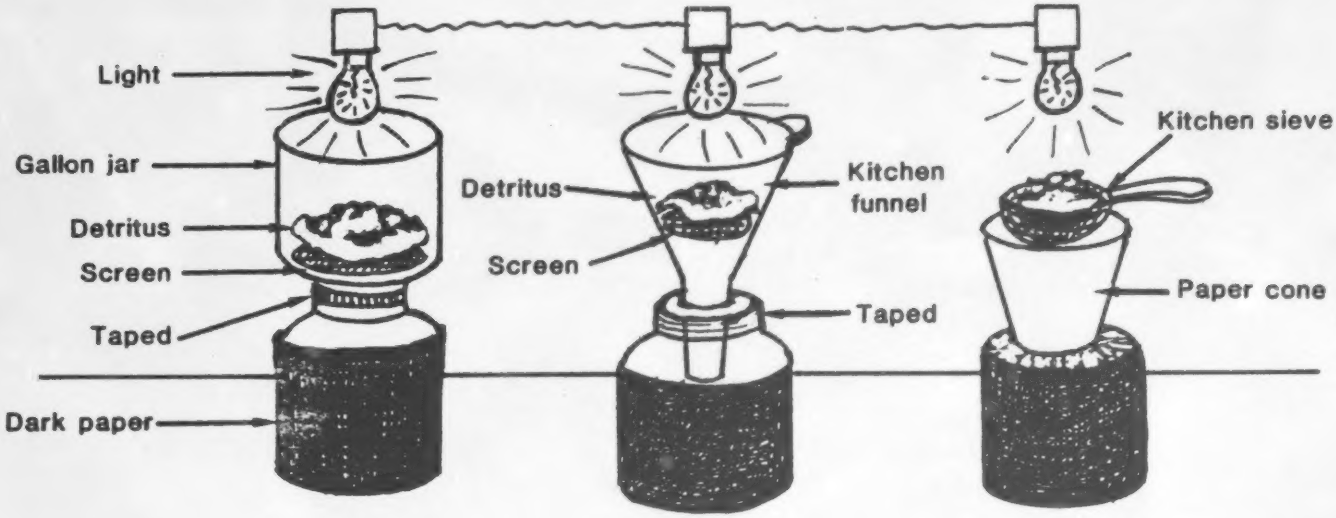


Place a generous scoop of dirt in the jar (about one-third full) and add water until the jar is about half full. Screw the lid on tightly, shake this mixture vigorously, and allow it to settle. Students or a student volunteer should observe the size of the settling particles. (The largest particles will settle first followed by succeedingly smaller particles. This demonstrates the sorting process in streams and in erosion; the smaller particles are carried further in the runoff, since they settle out less rapidly.)

Extension Activity 1: Is Soil Alive?

Background Information:

A Berlese Funnel can be made in several ways, but they all accomplish the same purpose (with varying degrees of ease and accuracy). The Berlese Funnel is used to force small animals out of their soil homes so they can be observed and counted. At one end of the funnel there's a light as a heat source; the funnel contains a soil sample; and at the opposite end there's a collecting vessel to trap the animals exiting the soil. Here are three ways to build a Berlese Funnel with common materials, but the funnels can be more elaborate and/or obtained commercially.



Materials:

- Berlese Funnels, as many as possible.
- Soil samples.
- Newspaper.
- Measuring cup or graduate cylinder.
- Hand lens.

Procedure:

This activity should be done prior to or following the resource person's visit, since some extended time is required. The work of Eileen Kladivko can be related here. These directions can be given to students.

Set up a Berlese Funnel as shown in the illustrations. Collect a soil sample and measure its volume (the sample should be able to fit in the funnel). Spread the soil on newspaper. Collect and record numbers and types of any larger animals. (It will be easier to find animals on a plain background, but that paper is more expensive than newspaper.) Next, place the soil in the Berlese Funnel, being careful to get all of it off the newspaper and into the funnel. Set the funnel aside for 24 hours and then observe and record what animals are found in the collecting jar. The funnel could be set aside for 24 hours again and newly collected animals observed. Nature guides from Golden Press on topics such as insects, spiders, insect pests, and pond life, and similar nature guides would be helpful in identifying the small animals living in the soil. At least a rich humus soil should be observed; but several different types of soils are recommended. Following these observations, students should be able to draw conclusions about the types and numbers of organisms living in various soils. Based on what they found and the size of their samples, they should be able to calculate how many animals are living in, say, a cubic foot of soil or in a field or in a woodlot. Depending on the variety of samples and what variables are represented, students should be able to draw conclusions about, say, the effect of using insecticides on soil animal populations.

Career Information

Over three million people, about four percent of American workers, are employed in agriculture and agribusiness. For years the number of people employed in agriculture has declined, but within such a large industry people with appropriate interests, education, experience, and resources can find employment. People with all kinds of educational backgrounds work in agriculture, but the steadily expanding technology and need for business acumen necessitate college training on top of firsthand experience.

Soil conservationists and scientists account for 12,500 workers in agriculture. Some of these people carry out soils research, but more advise farmers, range managers, and others in soil improvement. This career emphasizes outdoor work. After undergraduate work, and increasingly after graduate work, most soil conservationists and scientists are employed by the Department of Agriculture's Soil Conservation Service or by universitites.

Compared to soil science, geology is a much larger career field with 42,000 employed as geologists and geophysicists. However, these people work in a wide cross section of specialities from oil exploration to land use planning. Many geologists work a significant amount of time in the field, but indoor work in the laboratory, office, and classroom is included and may occupy the majority of a person's time. Undergraduate training and, as is the trend in most science careers, graduate work is required for entry level jobs. (To a significant extent, the need for field geologists governs the need for advance training. When demand is high for employees, less education is required.)

Well over 600,000 people are employed as engineering and science technicians across all fields. These people usually assist a professionally trained scientist or engineer, but many exercise a good deal of independence and responsibility in their work. (For example, while scientists like Mary, Richard, and Louis Leakey are credited with discovering remains of human ancestors, the vast majority of hours expended on those projects were put in by technicians. That dependence on technically trained people is true across the board in science and engineering.) Students interested in science should consider technical training as one career avenue. Some on-the-job training is possible, but technicians are also trained in the military, and in vocational, two year, and four year colleges.

Related Activities:

Evans, Eva Knox. The Dirt Book. Boston: Little, Brown. 1969.

McCormack, Alan J. Outdoor Areas as Learning Laboratories. Columbus, Ohio: ERIC Center for Science, Room 310, 1200 Chambers Road, 43212. 1979.

Outdoor Biology Instructional Strategies (OBIS) includes several soil activities. For information about OBIS, write Lawrence Hall of Science, University of California, Berkeley, California.

COMETS Profiles:

Cynthia Dusel-Bacon: Geologist.
Not entirely the typical description of a field geologist, this story of a courageous young woman and her encounter with a bear while on location in Alaska does provide insight into the breadth of possibilities of that career.

Gisela Dreschhoff: Physicist.
She does some of her field work in the Antarctica, a vast continent opened to women for only a little more than a decade.

For More Career Information Write:

American Society of Agronomy, 677 South Segoe Road, Madison, Wisconsin, 53711.

Soil Conservaton Service, U.S. Department of Agriculture, Washington, D.C. 20050.

Your state's university which offers agriculture.

Career Oriented Modules to COMETS Explore Topics in Science

TOPICS

- Geology
- Maps and Mapping
- Spatial Relations

Third Dimension

RESOURCE PEOPLE

- Geologist
- Architect
- Designer

THIS MODULE

Activity I

"3D Structures" shows how three dimensional structures can be depicted in two dimensional diagrams and how two dimensional diagrams can be used to mentally reconstruct the three dimensional objects. These skills are used by geologists, architects, designers, engineers, builders, city planners and others who use blueprints, diagrams, or maps. The main activity requires only reproduction of two structure sheets and is brief. Extension activities require additional, but simple equipment. The work of Tanya Atwater in plate tectonics and Mary Leakey in archeology can be related.

Activity II

"Hidden Structures" simulates skills used by geologists to piece together data from beneath the earth's surface in order to figure out how the earth is structured. Substantial advance preparation of simple equipment is required; but the activity itself can be brief. Students collect several bits of data about a structure hidden in a shoebox and then interpret the data to figure out the shape of the hidden object. Tanya Atwater used these skills and should be mentioned in this activity.

Activity III

In "2-D Tangrams" students reproduce two dimensional patterns out of simple geometrically shaped pieces. Simple equipment can be purchased or made rather quickly. The length of the activity can be very brief or extended well beyond the resource person's visit. Challenge cards are included. Both Tanya Atwater and Mary Leakey applied these skills.

University of Kansas School of Education Department of Curriculum and Instruction

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RELATED MODULES

Spatial skills have wide application in science, but this module is particularly intended for geologists, geographers, architects, city planners, builders, designers and other who use maps, blueprints, and diagrams.

Pearly Gates

Since the dentist uses several spatial skills, including being able to work with a mirror image, an activity using that skill can be found there.

Soil

Those activities include a study of some physical properties of soil and thus could be used by geologists other than soil scientists.

Fluid Follies

Physical properties of air and water are studied in this module and can be used by geologists.

Misc. Materials

Students make crystals and study their three dimensional patterns, relating this activity to the work of crystallographers, Rosalind Franklin and Dorothy Crowfoot Hodgkin.

WHERE TO FIND RESOURCE PEOPLE

Architects can be found in the yellow pages under that heading. Look for geologists in governmental agencies such as the U.S. Geological Survey. Land planners can be found in local and regional offices or at higher levels of government. Drafters, engineers, designers, and builders, all of whom use blueprints, can be found in manufacturing establishments and in the yellow pages under construction or building.

Chemists who use spatial skill to describe molecular and crystalline structures can be found at colleges and universities. Ask them to bring molecular models to your class. Orienteering and other outdoor groups use topographic maps in their avocations. Contact them through a store selling hiking and other outdoor gear.

Natural scientists and health career people use spatial abilities. For example, a physician palpates (feels) the internal organs and synthesizes this information to make a medical diagnosis much as students interpret landscapes in the "Hidden Structures" activity.

Women Applying Spatial Relations

Somehow people develop skill in working with two, three, or more dimensions of space and time. Putting tab A in slot B, combing hair while looking in the mirror, and arranging furniture illustrate our everyday applications of these skills. Mapping a coal seam, designing an instrument panel, and reading an X-ray or other sophisticated probe of the body demonstrates professional applications of these skills which are so essential to geologists, designers, archeologists and a host of other people in science and technology. Dr. Tanya Atwater and Dr. Mary Leakey are two women who have made significant contributions to an understanding of earth history, partially based on spatial evidence.

Dr. Tanya Atwater began her professional work as a marine geologist in the 1960's, the decade when plate tectonics blasted on the scene as an exciting, unifying theory that enabled interpretations of divergent observations and ideas, the best known idea being continental drift. However, plate tectonics also helps us understand why coal can be found in Antarctica, why there are earthquakes, and how mountain chains and other land forms were (and continue to be) produced. Tanya Atwater, a young researcher and teacher, continues her work which includes diving to the ocean floor to collect samples of the Mid-Atlantic Ridge; but even as a doctoral student and postgraduate, she contributed significantly to our understanding of the formations of the western American landscape, part of which is Mount St. Helens of recent fame. To tell her story requires some background information.

The theory of plate tectonics holds that the earth is an evolving body with a surface (lithosphere) composed of about 20 massive, rather solid plates about 50 miles thick "floating" on a molten, fluid interior. One can imagine tearing an orange peel into 20 pieces and then replacing these pieces on the orange. The juicy orange is analogous to the earth's interior and the pieces of rind are like the earth's plates. The replaced rind pieces are more-or-less in place relative to each other, but they can be moved around. The movement of the earth's plates is extremely slow from the point of view of our lifetimes; but from the perspective of the millions of years of geologic time, even this slow movement can be quite significant. The continental drift application of plate tectonics asserts that the present continents once were much closer together, forming a giant supercontinent, Pangaea, the pieces of which moved to their present locations (and continue to move).

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The plates can move relative to one another in one of three ways. Two plates can slide sideways, rubbing past each other. An example of this movement can be found in the San Andreas Fault where the North American Plate and the Pacific Plate are sliding past one another. The plates' relative movement isn't smooth; the movement is jerky and each "jerk" is an earthquake.

A second type of movement occurs when one plate slips under another plate. As the first plate sinks (is subducted), it heats up and exerts an upward pressure under the overriding plate. This upward force produces mountains; and that is how the Andes Mountains have formed.

A third type of movement occurs where two plates are moving apart. As this breach between two plates is produced, molten, subterranean material works its way upward, bringing younger rock to the surface. An example of this action can be found in the midst of the Atlantic Ocean floor where a roughly north-south, marine mountain ridge has been found and is still being explored (by Atwater and others).

About a decade ago Tanya Atwater applied plate tectonics and their three types of movement to western North American geology. As in virtually all areas of science, she did not work alone; but her published work helped unravel this complex picture.

In the past the North American continent was the above water portion of the North American Plate. To the west of this plate were found two plates, first, the Farallon Plate and then to its west, the Pacific Plate. Both the Farallon Plate and the Pacific Plate were moving east, with the Farallon Plate subducting (diving down) beneath the North American Plate and eventually becoming completely submerged, causing considerable mountain building activity in the process. The Farallon Plate moved east more rapidly than the Pacific

Plate, so they were moving apart relative to each other creating a rift (mountain ridge) between them. After the Farallon Plate was completely submerged, the trailing Pacific Plate "bumped" into the North American Plate. However, instead of being subducted as the Farallon Plate had been, the Pacific Plate moved north relative to the North American Plate. That's where we are now. The Farallon Plate had disappeared beneath the North American Plate (with the Rockies serving as visible testimony to that occurrence); and the Pacific Plate rubs past the North American Plate (with the activity around the San Andreas Fault pointing out that process).

While Dr. Tanya Atwater has studied massive land features of continental proportions, Dr. Mary Leakey has worked with material that can usually be hand held. Along with her now deceased husband, Louis, and their son, Richard, Mary Leakey has combed the Olduvai Gorge and other eastern African areas and helped piece together the fascinating story of human evolution.

While her husband was more flamboyant and repeatedly in the public's eye, Mary Leakey was ever the careful worker, painstakingly sifting through deposits to find the smallest of remains, carefully mapping the study site so the relative position of each specimen would be known precisely, piecing together the evidence, and finally carefully documenting the discovery in scientific publications. In 1942 near Nairobi, Kenya, she spotted the world's largest collection of prehistoric handaxes, adding immeasurably to our understanding of those people's culture. In 1947 at Rusinga Island in Kenya's portion of Lake Victoria, Mary Leakey found the first remains of *Proconsul africanus*; and in 1959 at Olduvai Gorge in Tanzania, she discovered the remains of *Australopithecus boisei* (or Nutcracker Man in the popular press, so named for its huge teeth). As she had done earlier with *Proconsul*, she carefully reconstructed the *Australopithecus* skull which was found in about 400 seperate pieces and took 18 months to put together!

Mary and Louis Leakey and then their son, Richard, made a good team. Louis's flair for publicity raised the money necessary for their scientific expeditions; and Mary's painstaking persistance enabled the expeditions to be completed. Mary's careful piecing together of evidence undergirded their scientific work; and Louis's excited seizure of new finds projected their work forward to new interpretations. Louis was often in the limelight and Mary was rarely mentioned in the press; but in 1962 the National Geographic Society awarded its highest prize, the Hubbard Medal, jointly to the Leakeys.

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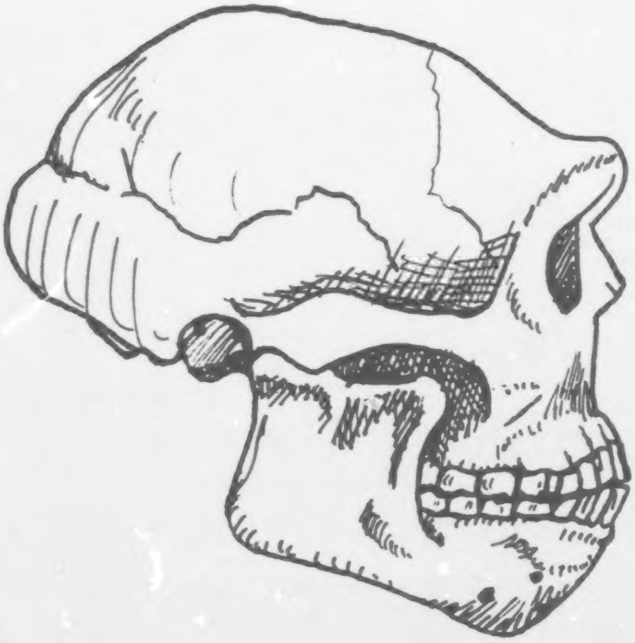
Our understanding of our ancestry continues to grow. The precise place of Proconsul africanus and Australopithecus boisei in that puzzle and their importance to its solution may diminish; but certainly those discoveries have been instrumental in propelling modern science's understanding of our ancestry and close relatives. Louis Leakey died in 1972, but Mary and Richard Leakey continue their work. Also, growing out of Louis Leakey's desire to understand better the behavior of our ancestors and relatives and initially under his auspices, three women - Jane Goodall (chimpanzees), Dian Fosey (gorillas), and Birute M.F. Galdikas (orangutans) - have dedicated years of study to these animals. (See Outdoor People for reference to the work of these ape researchers.)



Activity I: 3-D Structures

Materials:

- Structure sheets #1 and #2 for each student.
- Wooden blocks to make the two structures on sheet #1 (optional).
- Blueprint and the object it depicts (optional).

Procedure:

This activity is brief and requires minimal equipment. Only the reproduction of the structure sheets is needed. Optionally, the resource person may use blocks to reproduce and show students the structures shown on sheet #1.

Give students a copy of structure sheet #1 which shows two different block constructions. After explaining the first sheet, distribute and explain structure sheet #2 which shows top and side views of the two block constructions. Students should figure out and record which structure from sheet #1 is depicted in each of the six views on sheet #2. Not all sides of the structures are shown on sheet #2. After students have completed their work, their answers can be checked with this key. a) X b) Z c) Z d) X e) Z f) X

At this point a drafter, architect, engineer, or other resource person could show how blueprints are translated into actual structures and vice versa. A geologist, city planner, building contractor, or other resource person could "read" geologic, soil, or similar maps to show how they translate the two dimensional map into an understanding of the three dimensional reality.

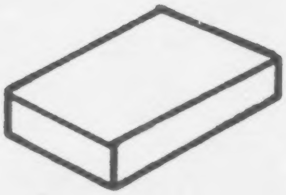
Extension Activity 1: Structures in Depth

Materials:

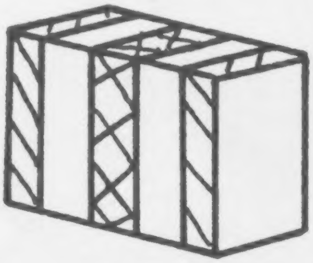
- Five tabular pieces of wood, plastic, cardboard, modeling clay, or other material. The pieces should be nearly identical in length and depth, but differ in width and color.
- Map of the pieces.
- Paper and pencil.

Procedure:

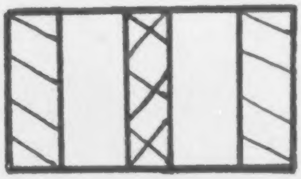
Prior to meeting the students, pile up the five pieces and make a top view map of the pieces. This map preferably should be reproduced for students or a single copy could be enlarged to poster size for the entire class to view. If this activity is done as a demonstration, less equipment is needed.



Tabular object



Construction



Plan view

Ask students or a single student to assemble the five pieces so that the top of their structure looks like the map. Next they should lean their structure to one side and then sketch the top view of this new structure. This sketch should be compared with the original map. (The bands of color should be in the same order, but the bands will be wider.)

Present this problem to students. Suppose you are a mining engineer or geologist and the middle piece of the tilted structure contains gold halfway down. Ask them to mark on their map where to drill straight down to find the gold. (In the structure tilted to the right, they should drill down through some of the left-hand layers to find the gold in the middle layer).

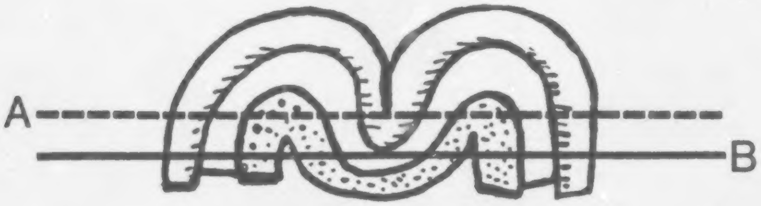
Extension Activity 2: More Structures in Depth

Materials:

- Three pieces of modeling clay of different colors.
- Knife.
- Toothpick.
- Waxpaper.
- Paper and pencil.
- Crayons (optional).

Procedure:

Direct students to flatten, stack, and bend the clay as shown in the illustration. Placing waxpaper between layers keeps the clay clean. Cut the clay along the dotted line A shown in the diagram and draw the top view which is then exposed. They may color their drawings; and the drawings should be labeled "Top View A."



Ask students to predict how the structure would change if it were "eroded" down to line B. They should draw a new top view to show their predictions and label this new drawing, "Top View B."

Next, ask students to mark on their "Top View A" where they would drill for oil if it collected in the middle layer at the base of a U-shaped fold. They could check their predictions by "drilling" with a toothpick and finding out whether they found oil. (They should "drill" through the strip of the top layer left exposed when eroded to line A and find the middle layer below.) Finally, they can check their drawings of "Top View B" by cutting the clay down to line B.

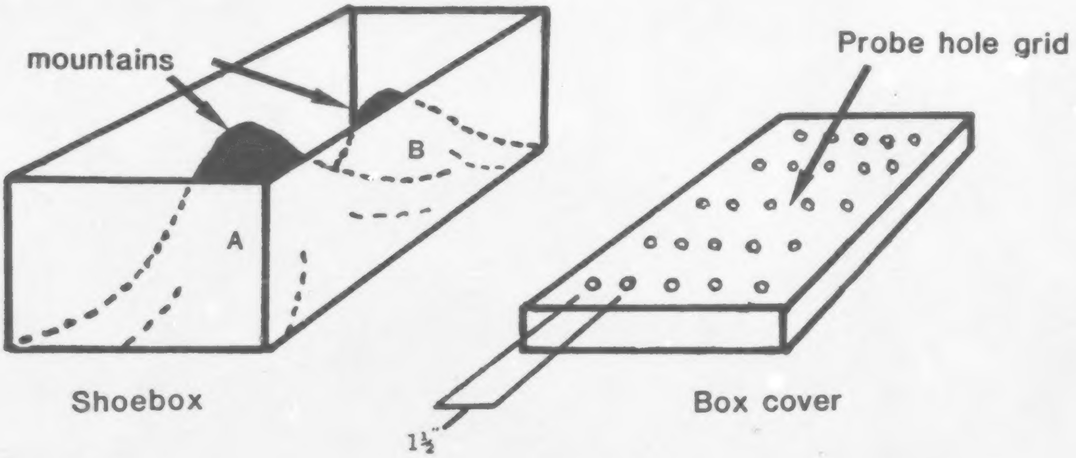
Activity II: Hidden Structure

Materials:

- Shoebox with lid.
- Object in shoebox (see directions below).
- Cork borer, screwdriver, or some other object for punching holes.
- Pencil, dowel, or similar object for probe.

Directions for Making Box:

Anchor down an irregularly shaped object in the bottom of a shoebox. Punch holes in the lid of the shoebox approximately every 1½ inches in a grid pattern. Tape the lid securely to the shoebox.



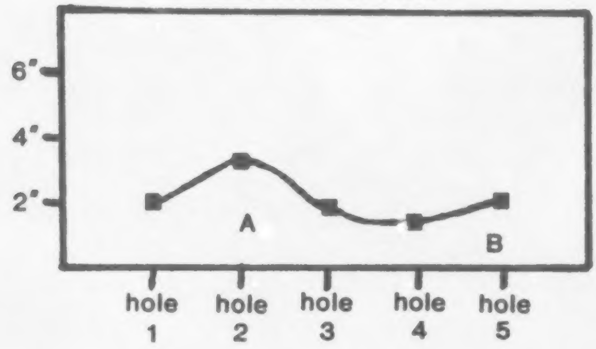
The irregularly shaped object could be two pieces of wood. Alternatively chicken wire "mountians" could be shaped and fastened to the bottom of the box. The chicken wire should then be covered by paper mache (strips of newspaper dipped in dilute white paste).

Use of Box:

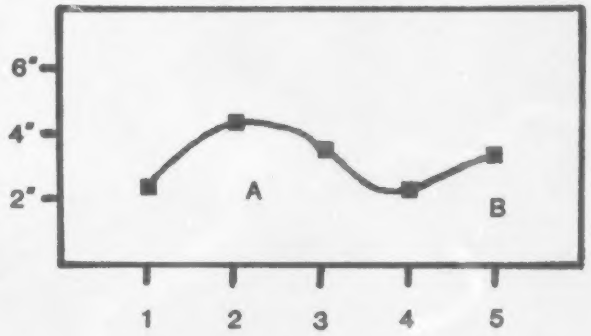
By inserting a pencil vertically through a hole in the top of the box, the distance down to the object can be measured. This measurement can be subtracted from the height of the box, yielding the height of the object at that point. Similar calculations of the height of the object can be obtained for each hole; and these data can be put together to get a picture of the object's shape. If the object is a familiar object, the students can use their data to figure out its identity.

To help students keep track of their data, have them record their measurements for each row of holes on graph paper. They can then connect the dots to get a general notion of the object's shape along that row of holes. (In this illustration, mountain A is higher than mountain B; and both mountain A and mountain B have climbed between these two rows.)

First Row of Holes



Second Row of Holes



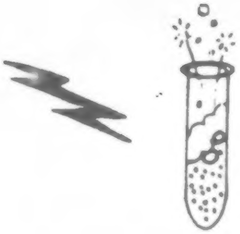
Procedure:

This activity can be done prior to the resource person's visit. The activity can be done in a learning center, using fewer boxes; or the activity can be done by an entire class, but more boxes would be needed. Students could bring materials to school and make their own boxes under teacher supervision. Then they can try to figure out the shapes of each other's boxes; but encourage them not to make their boxes too complicated.

Alternatively, the resource person could use one box as a demonstration. Have a student come forward and collect data. This information can be put on the blackboard or overhead projector.

Whichever way the activity is done, prior to or starting the resource person's visit, the resource person should describe how in their field data are collected, compiled, and then put into maps such as soil, geologic, or drainage maps. At this point the work of Dr. Tanya Atwater and/or Dr. Mary Leakey could be described. Stress the importance of being able to interpret three dimensional data in careers such as geology, architecture, and drafting.

Activity III: 2-D Tangrams

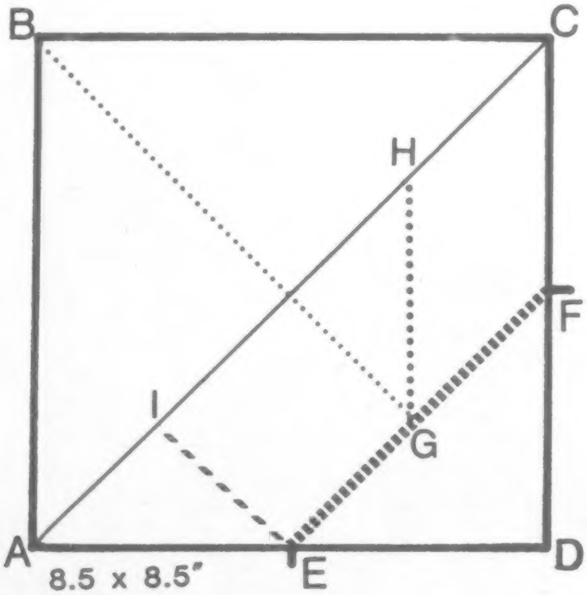


Materials:

- Tangrams.
- Patterns for tangrams.
- Challenge cards (optional).

Making Tangrams:

Tangrams are sets of seven geometrically shaped pieces which can be put together in a variety of ways to make more complex patterns. Tangrams and tangram patterns can be purchased; or they can be made out of poster board with a paper cutter following this pattern. To make the pattern on 8½" x 11" paper, cut off the bottom of the paper to make an 8½" x 8½" square. Draw the diagonal line AC. Locate points E and F, the midpoints respectively of sides AD and CD. Connect E and F. Draw line BG which falls on diagonal BD, but stops at G. Draw line GH parallel to CF and line EI parallel to BG.

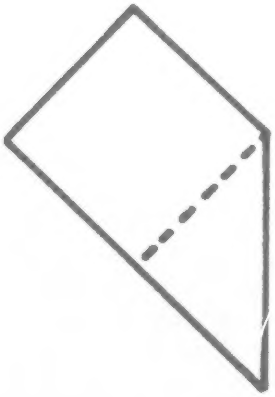


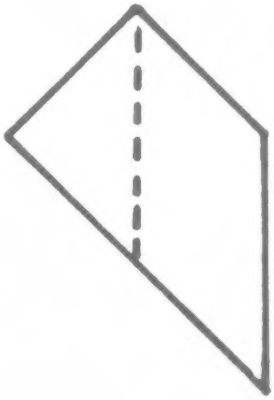
Procedure:

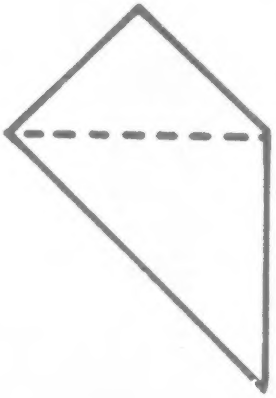
Tangrams could be used in the classroom in many ways. Described here is one procedure that a resource person could use to briefly introduce students to tangrams. This activity can be used, for example, by mechanical engineers and others who read and interpret blueprints. They need to be able to figure out from the bluprint how things fit together; and conversely, then need to be able to draw blueprints from an idea or the actual object. Encourage the resource person to bring, if possible, a blueprint and the object it depicts. Relate here how Mary Leakey figured out how skeletal remains fit together and how Tanya Atwater cut up and fit together pieces of paper to explain North American geology. (See 1980 Science Year, Chicago: World Book - Childcraft, for a description of this latter incident.)

Give each student the two small triangles from a tangram set. Ask them to make a square, then a triangle, and then a parallelogram. (If a particularly brief activity is desired, the activity can be ended here and the career person could turn to how this activity is related to career activities.) Give them the medium sized triangle; and with these three triangles they again should make a square, triangle, and parallelogram. Give them one of the two large triangles and have them make the square, triangle, and parallelogram with these four pieces. They should also notice that the large triangle can be duplicated using the other three pieces.

Next, give the students a small triangle, the medium triangle, the parallelogram, and the square. Collect the remaining pieces or have students put them aside. Have students make a lopsided diamond in three different ways using only two pieces each time. Here are three solutions to the problem.







The activity can be ended here to allow more time for relating the activity to the resource person's career, or the activity can be continued by giving students the remaining tangram pieces and one each of the COMETS Challenge Cards. Additional tangram activities can continue to fascinate students long after the resource person's visit.

Career Information

Architects are hybrids, a cross between an artist, engineer, and business person. They design buildings and other structures to be functional, safe, economical, and aesthetically appealing. Architects take the client's rough ideas and translate those ideas into plans which meet the need. In this respect, they are artists and engineers. However, they frequently are involved in managing the construction and/or supervising the work. Licensed architects are responsible for the safe operation of buildings done to their specifications.

Much of the creative work of the architect is done alone at the drawing board, but they also work with clients and others involved in the project. To be qualified for their job, they need at least a four year collegiate program that includes courses in engineering (e.g., characteristics of materials), mathematics, and physics. Following graduation, they need at least two years experience and usually more before they are eligible for a license. 54,000 architects practiced that profession in 1978.

Landscape architects, 14,000 strong in 1978, also require artistic abilities, but their science coursework comes from the biological sciences with specialization in botany and horticulture. They design plantings, sidewalks and other structures which make a pleasant, functional outdoor environment. They work both outdoors and indoors, first visiting the site, then making plans, and finally overseeing the job.

Drafting, a related field, employed 296,000 people in 1978. Drafters take the rough ideas and/or sketches for a piece of equipment, a building, or some other object and translate those ideas into precise drawings (blueprints) and specifications for the finished object. Drafters have varying levels of responsibility from filling in details on drawings initiated by someone else to supervising the entire operation. Their training almost always includes a high school diploma and in most cases technical, post-high school coursework. Usually drafters specialize during training and/or on the job in areas such as mechanical, electrical, or building drawing. Their training includes some mathematics and physical science as well as drawing and related courses.

Geographers comprise another career group which relies heavily on two and three dimensional spatial skills. Working largely at colleges and universities or for governmental agencies, geographers do research and teaching in the social, economic, environmental, and physical sciences. Some are involved in interpreting remote sensing data gathered by satellite. Some work in the area of urban planning and land use. Most specialize in some area such as agricultural, historical, or regional geography. All geographers complete at least a bachelor's degree and most continue into graduate training before entering the job market.

Related Activities:

Geoblocks, *Mapping*, and *Tangrams*. Published by McGraw-Hill Book Company, 1221 Avenue of the Americas, New York, New York 10020.
Three teacher's guides and optional equipment suggest activities for studying two and three dimensional space and patterns.

Women and Geosciences:

Space for Women: Perspectives on Careers in Science. Washington, D.C.: Smithsonian Institute.
A free booklet based on a symposium for women on careers in astronomy, astrophysics, earth and space sciences.

COMETS Profiles:

Janice Morgan: Installation Foreman.
She started out learning how to climb the poles and advanced to the supervision of an installation crew. Janice Morgan now makes sure that telephone installations are done according to plan.

Marsha Turner: Architectural Engineer.
As a project architect for the telephone company, Marsha Turner translates information from telephone user groups into designs to meet those needs.

For More Career Information Write:

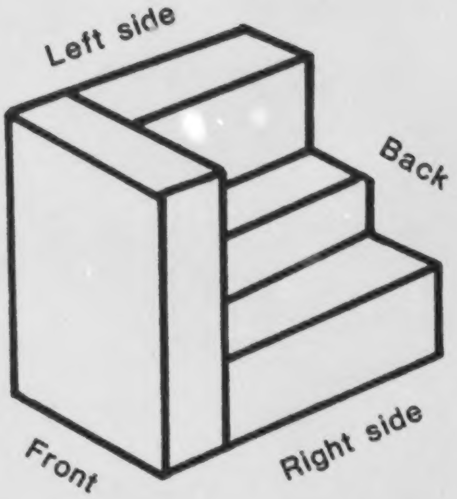
American Institute of Architects, 1735 New York Ave., N.W., Washington, D.C. 20006.

American Institute for Design and Drafting, 3119 Price Road, Bartlesville, Oklahoma 74003.

American Society of Landscape Architects, 1900 M St., N.W., Washington, D.C. 20036.

Association of American Geographers, 1710 Sixteenth Street, N.W., Washington, D.C. 20009.

Structure Sheet # 1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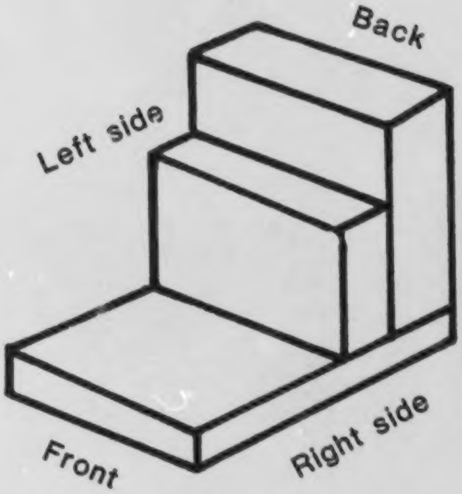
STRUCTURE X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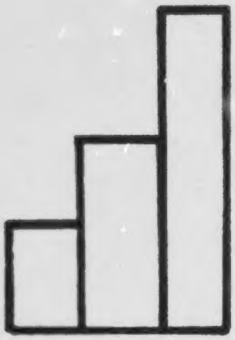
STRUCTURE Z

Structure Sheet #2

A



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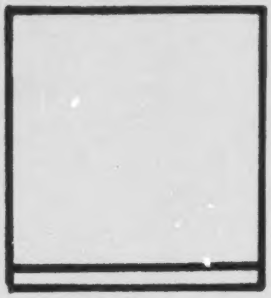

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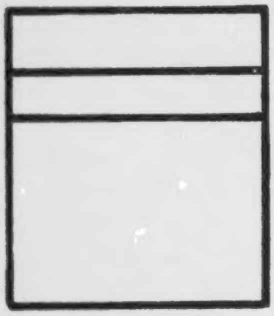

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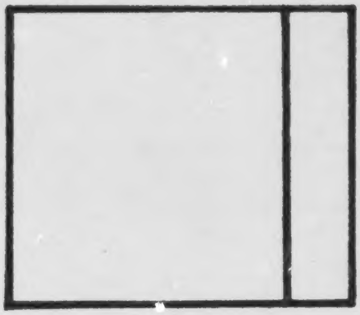

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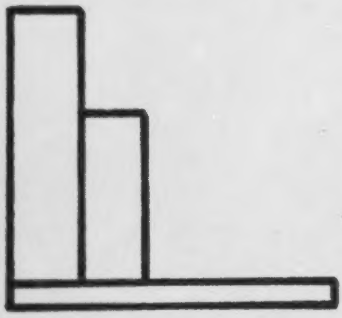

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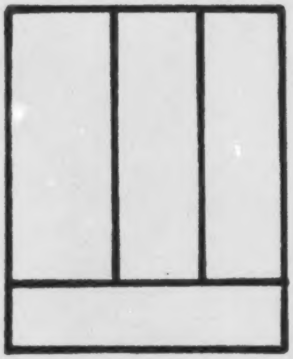

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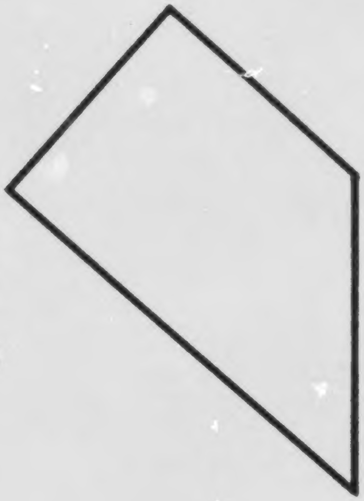
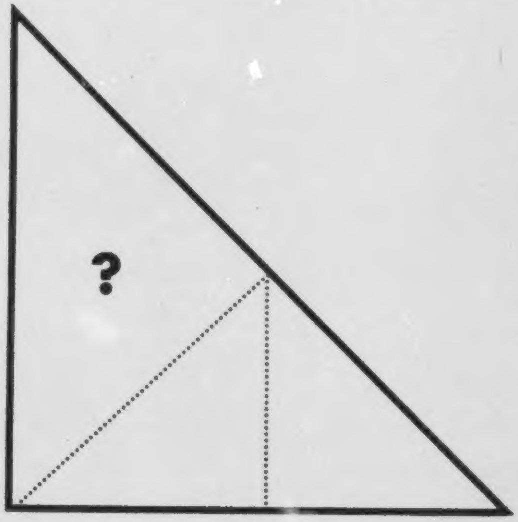
COMETS Challenge Card



Third Dimension

Make this shape with three different combinations of two pieces.

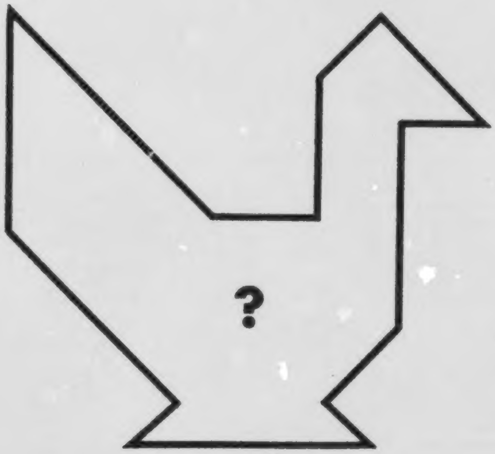
COMETS Challenge Card



Third Dimension

Make triangles with 2,3,4,5, or 7 pieces.

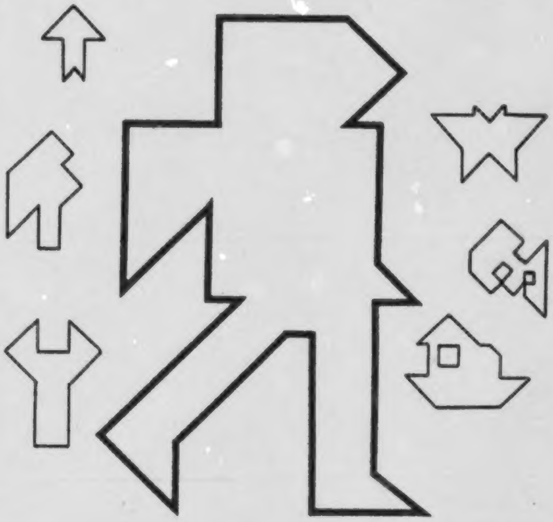
COMETS Challenge Card



Third Dimension

Create an animal with seven pieces .

COMETS Challenge Card



Third Dimension

Create a shape and give its outline to a friend to reproduce.

Career Oriented Modules to COMETS Explore Topics in Science

TOPICS

Airplanes

Air Pressure

Astronomy

Through the Air

RESOURCE PEOPLE

Pilot
commercial or private

Aeronautical Engineer

Astronomer
professional or amateur

THIS MODULE

Activity I

"To Fly" includes directions for making a paper helicopter which could briefly and intriguingly begin a visit from a pilot or aeronautical engineer. Only pieces of paper are required. One extension activity with model airplanes teaches about flight and manipulation of variables. The accomplishments of Amelia Earhart (see "Women, Flight, and Beyond") can be related here.

Activity II

In "Keeping the Plane Up," Challenge Cards guide students to investigate various facets of air pressure. The activity can be brief or extended and uses fairly simple equipment. In an extension activity students design parachutes, which can be related by the resource person to aerodynamics. Joanne Simpson's use of air's buoyancy to make rain can be mentioned here.

Activity III

Students collect observations of the moon's shape and location for one month in "Moon-struck," and then they interpret these observations in order to figure out the relative movement of the moon, earth, and sun. In an extension activity, "Nighttime Sky," students observe the stars, planets, and moon. This activity is designed for resource people who have an avocational or vocational interest in astronomy, and the work of Jocelyn Bell Burnell can be related here.

University of Kansas School of Education Department of Curriculum and Instruction

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RELATED MODULES

Through the Air is intended for pilots, aeronautical engineers, and astronomers who can also be used with any of the following modules.

Light and Sight

Students study lenses and optics. The work of Annie Jump Cannon, an astronomer, is described.

Third Dimension

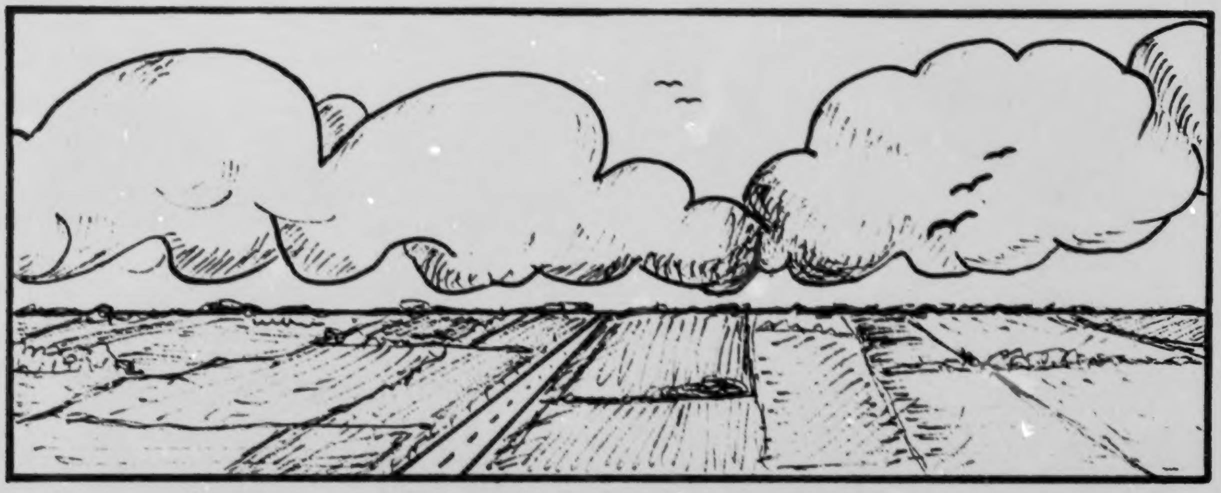
Various two- and three-dimensional activities are included and could be related to the resource person's need to understand spatial relationships. (One hopes the pilot knows where's up!)

Constructions

One activity deals with center of gravity, with which a pilot must be concerned in order to load and smoothly fly the plane.

WHERE TO FIND RESOURCE PEOPLE

. Pilots can be found at the nearest airport. Look both for commerical and private pilots. Use the yellow pages to find airports, airlines, aircraft sales, and aircraft schools. A military base may also supply these resource persons, even if the base is not an air base. Aeronautical engineers are employed by manufacturers. Astronomers may be contacted at a university among faculty and students. A librarian or store selling telescopes may refer you to people interested in astronomy.



Women, Flight, and Beyond

Look at some of the squiggles on the EKG illustration in Healing Techniques. How can you recognize that a person is suffering a heart ailment? To the untrained eye, such recognition is difficult; but to the trained eye of the resource person in Healing Techniques, each wiggle has meaning. But what if a new wiggle appears? How do you decide whether the new wiggle is an accident with little meaning or something significant? Such a dilemma faced Jocelyn Bell Burnell as a Cambridge student assigned to look after the print-outs from a radio telescope.

She knew that artificial signals--for example, a car's engine or a nearby CB--could be picked up by the radio telescope; so when Burnell saw a new squiggle one day in 1967, she knew it could have come from any number of sources. However, the only logical explanation was that the squiggle was due to some extraterrestrial source, so she alerted her professor, Anthony Hewish; and they whimsically labeled this new signal, LGM, for Little Green Men. After all, perhaps some being from outer space was attempting to signal earth! Jocelyn Bell Burnell continued her vigilent looking for more LGM's; and after several weeks of observation, she had found three more in different parts of the sky.

The halfheartedly held notion that LGM's really came from some source of intellignet life was discarded, because it seemed extremely unlikely that suddenly four groups of intelligent life in four diverse parts of the universe

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would start to signal earth with the same message on the same frequency. The name, LGM, was charged to pulsars, indicating an object emitting a pulsating signal. But still the question remained. What could be causing the squiggles? What were the pulsars? Demonstrating again the synergism of theoretical and empirical science, someone on the Cambridge team remembered a paper from the 1930's postulating something called a neutron star. A neutron star was theorized to be a collapsed star, incredibly dense with the mass of a star but a diameter of only ten miles. (By comparison, our sun is a little less than a half million miles in diameter.) Unlikely as a neutron star sounded, an even more dense star, a black hole, had also been postulated.

After much speculation and calculation, the pulsars first noticed by Jocelyn Bell Burnell were plausibly explained as neutron stars and black holes. A theory first spun nearly thirty years earlier had finally received some experimental backing. (For this discovery Anthony Hewish and Martin Ryle won the Nobel Prize.)

Another example of theory which needed to wait years to be done in practice is provided by the work of meteorologist, Joanne Simpson. In 1946, Vincent Shaefer had found that small pellets of dry ice could convert supercooled water vapor into a cloud. For 20 years scientists, including Joanne Simpson, tried to make rain by applying Shaefer's seeding idea. Not much success was experienced, but a lot of observations were gathered. What Simpson and her team concluded was that the chief factor that made cumulus clouds grow into rainmakers was buoyancy. Simpson knew that when water vapor condensed into liquid, energy was released and this energy warmed the vapor; and she believed this was happening in clouds. (This concept is applied in reverse to make refrigerators cool.) Warmer air is less dense than cooler air, which means that warmer air is, therefore, also lighter. Since lighter things rise, this condensing water vapor could rise, giving the rainclouds their billowing effect. These growing clouds, she reasoned, would eventually reach a critical point where rain would begin.

Experiments testing this theory of Joanne Simpson and her colleagues have been undertaken on an ever-increasing scale since 1968, and at each stage more rain than what one would expect by chance has occurred. The experiments continue here and in other countries, and Simpson's buoyancy model of cloud growth is acquiring more and more validation.

The work of Jocelyn Bell Burnell can be related to the astronomy activities of this module, and Joanne Simpson's work with buoyancy of warm air in clouds can be related to the second activity which deals with air pressure. The accomplishments of Amelia Earhart, America's premier woman pilot, can be related to Activity I.

A narrow definition of a scientist as those people professionally trained in science leads to the conclusion that Amelia Earhart was not a scientist. Certainly she did not view herself as one. What she was was a free spirit who had been smitten with the life of flying--flying where no one or at least few had flown before. She crisscrossed the oceans and continents at a time when people still ran out of their homes to see a plane go by. Finally, in 1937 she decided to fly around the world at the equator; and near the end of that mission, she, her navigator, and her plane went down in the Pacific. Stories linger on about Amelia Earhart's survival on this or that Pacific isle, but surely she perished. Now she lives in statuary honoring her and her accomplishments and in the minds of many people.

What did Amelia Earhart do for science? In one sense, each flight was an experiment feeding information back to airplane builders and operators, just as flights of the space shuttle yield information to improve the shuttle. But more importantly, people like Amelia Earhart--people with daring and vision--

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compelled aeronautics forward to new achievements. If someone wants to fly around the world, then engines need to be developed, navigational instruments have to be perfected, and communications devices must be improved. Amelia Earhart was a driving force who cajoled, urged, pushed, and compelled flight science and technology forward.

Activity I: To Fly

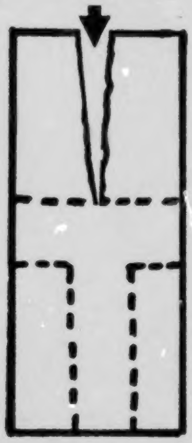
Materials:

- For each student one piece of paper about 2" x 8½". (Slice a standard 8½" x 11" piece of paper into about six pieces with a paper cutter.)

Procedure:

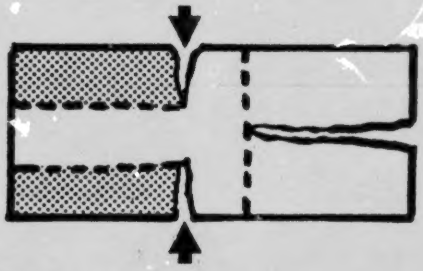
This very brief activity has great value for a pilot or aeronautical engineer to capture students' interest. Some variables can be studied, or after the initial "flight" the resource person could move to talking about their vocation or avocation. Give these directions to students while demonstrating the procedure without revealing what is being made. Keep the result a mystery.

Hold the paper in two hands with the long sides up and down. Tear down the middle of the sheet about one-third way (see illustration).



Step 1

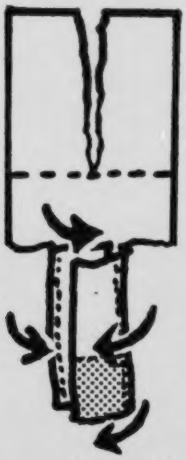
Turn the paper sideways with this tear to your right. One-half inch to the left of the first tear, tear down one-third way. (This second tear will be a little longer than ½" and will be at right angles to the first tear.) Turn the paper upside down and make a third tear directly opposite and matching the



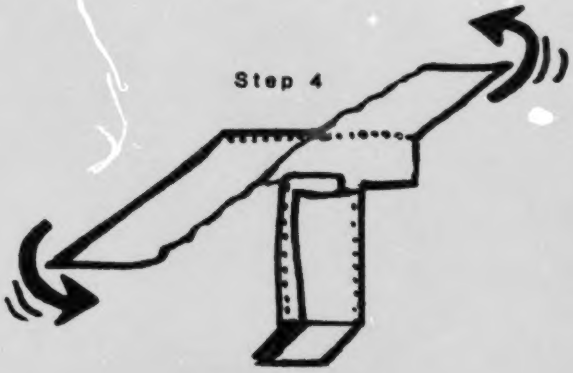
Step 2

second tear. Next fold over the shaded area shown on Step 2 to make a "lollipop" as shown in Step 3. Then fold the last half inch of the "lollipop stick" (shaded area of Step 3) at right angles to the "stick." Finally, fold over the "bunny ears" in opposite directions without creasing the ears.

Step 3



Step 4



Have all the students stand and hold the final product high over their heads with the foot of the "lollipop" down. (Remember to demonstrate each of these steps as you give directions.) On your command, have students drop their helicopters, which will spiral down to the ground. Allow some time for play and fascination.

The activity can be ended here or some questions could be posed.

- Do the helicopters turn clockwise or counter-clockwise? (It depends on your point of view. Viewed from above it will turn one way and from below, the opposite.)
- Can you make it turn the opposite way? (Adjust the "bunny ears" to flop in the opposite direction.)

Extension Activity 1: Model Planes

Materials:

- Paper airplanes or balsa model airplanes.

Procedure:

This activity can decay into chaos; or given proper direction, it can teach students about concepts of flight and/or the manipulation of variables and collection of data. This activity can be done as a contest--make a plane that will fly the farthest, make a plane that will stay in the air the longest, make a plane that will carry the greatest load for at least a 25-foot flight, and so forth. Using this latter option, the resource person could comment on the products after the contest was completed. In any event, give students clear directions such as the following.

Build a paper airplane (or balsa model). Use any design you know. Use paper clips to add weight to the plane and determine where the clips should be placed and how many should be used to yield the greatest flight distance.

Activity II: Keeping the Plane Up

Materials:

- String and two balls, balloons, or other objects. (See Challenge Card for materials and directions.)
- Quart jar or larger with wide opening (e.g., peanut butter jar), plastic bag (e.g., bread wrapper or baggie without holes), and a rubber band. (See Challange Card for materials and directions.)
- Plastic syringe and cup of hot water. (Use discarded, cleaned syringe from physician. Needle should have been discarded. See Challenge Card for materials and directions.)
- Yardstick (or lath planed to thickness of yardstick), newspaper, and broad table top. (See Challenge Card for materials and directions.)

Procedure:

Planes can stay up because of air pressure. Despite being able to recite that air exerts 14.7 pounds of pressure per square inch, we have difficulty conceiving the enormity of that force. These Challenge Cards activities are intended to provide students graphic illustrations of air pressure and some of the natural laws regarding air pressure. Challenge Cards could be used in various ways. For example, individual cards could be given out; students could collect the materials at home, and activities done at home or school. One set of materials could be placed in learning centers for students to work with individually. The resource person could do one of the activities as a demonstration; or enough materials could be gathered by the students, teacher, and/or resource person for one activity, so that each student could do the activity under the resource person's directions. Here are some comments about each card.

When one blows between two suspended balls, balloons, apples, or whatever, they will move together, because the moving air between the balls exerts less pressure on the balls and the air pressure on the outside of the balls pushes them together. This is a demonstration of Bernoulli's Law--the faster a fluid (liquid or gas) moves, the less "sideways" pressure it exerts. That is what makes the plane rise.

When one pulls up on the bag in the jar, the space between the bag and jar increases. Since the rubber band is in place, no (or little) air can get into this space, so the air pressure in that space is reduced. Since the air pressure inside the bag (where the hand is) is not affected by the hand pulling on the bag, this air pressure remains constant. Pretty soon there is quite a difference between the air pressure in the bag (constant) and the air pressure between the bag and jar (reduced). Thus, in order to continue pulling the bag out, you have to pull against this air pressure with relatively little help from the air between the jar and bag. This illustrates (1) the great force of air pressure which we take for granted because it is around us all the time, and (2) the natural law that as a volume of gas in a closed container increases, the pressure exerted by that gas decreases (and vice versa, as can be shown with this material by starting with the bag fluffed up outside the jar and then pushing in on the bag. With the rubber band in place, the air between the bag and jar is forced into a smaller volume, thus increasing its pressure).

One sheet of newspaper (two pages opened up) spread over the yardstick on the table acts like a sail. When one pushes down gently on the yardstick, the other end slowly lifts up the sail. However, when one chops rapidly on the yardstick, the sail pushes against the air which holds that end of the yardstick down. A quick karate chop can snap the yardstick. Caution: If the yardstick is too thick and does not break, you could break your hand! Thus, you might want to substitute a bat for your hand.

The syringe and hot water demonstrates that boiling is controlled both by the temperature of the water and air pressure being exerted on the water. As most cooks who live at a high altitude know, water boils there at a temperature lower than 212°F. This phenomenon is due to reduced air pressure at higher altitudes. (The air is "thinner.") Draw some hot (not boiling) water about a quarter of the way into the syringe. With your finger over the open end of the syringe (to prevent any more air getting in), draw back slowly, but steadily, on the plunger. Eventually the water will boil as the air pressure inside the syringe is reduced. If it does not boil, use hotter water and/or a syringe with a tighter fitting plunger. This activity demonstrates again that, when the volume of air expands, the air pressure decreases. This is not a demonstration of the idea that warmer air exerts greater pressure.

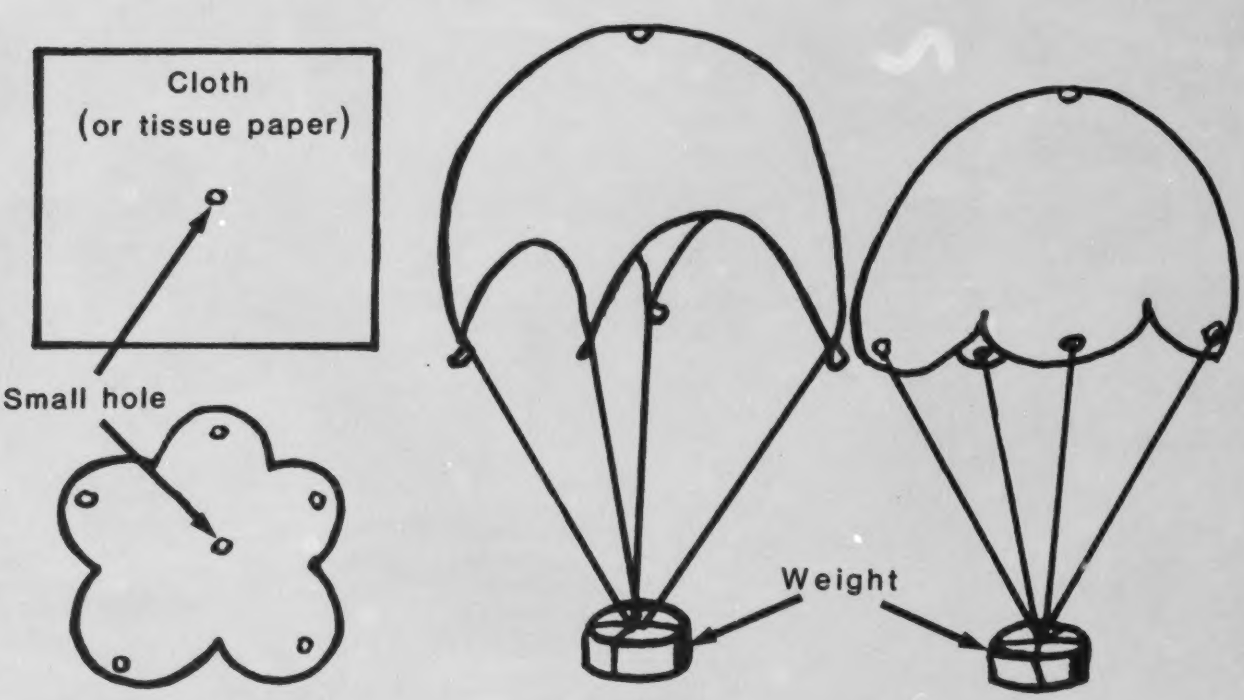
Extension Activity 1: Parachutes

Materials:

- Tissue paper, plastic wrap, cloth rags, or similar material.
- String.
- Gum-backed hole reinforcers.
- Scissors.
- Raw eggs (optional) or washers or other weights.
- Tall building.
- Soap, water, newspapers, and other cleaning materials (in case of accident).

Procedure:

Directions for this activity should be given and then several days allowed to pass to give students a chance to make their parachutes. The resource person could be present for the trial runs.



Ask students to make parachutes according to certain specifications (which can be decided by the students and/or the teacher). Here are some possible challenges.

- Drop a parachute from, say, five feet so it will land in a bullseye of predetermined diameter. Points could be awarded for accuracy and a game played with the winner getting the most points.
- Design two parachutes to be dropped from a predetermined height, say, five feet so that one parachute will be at least a foot off the ground when the other one lands.
- Make a parachute that can carry a raw egg attached to it, so that the egg does not break when dropped from a predetermined height (say, a second story window).

After the contest a pilot or aeronautical engineer could comment on aircraft design and aerodynamics. The parachutes were made to take advantage of the force exerted by air to slow their fall, but a plane is made to reduce air pressure's effect which causes a drag.

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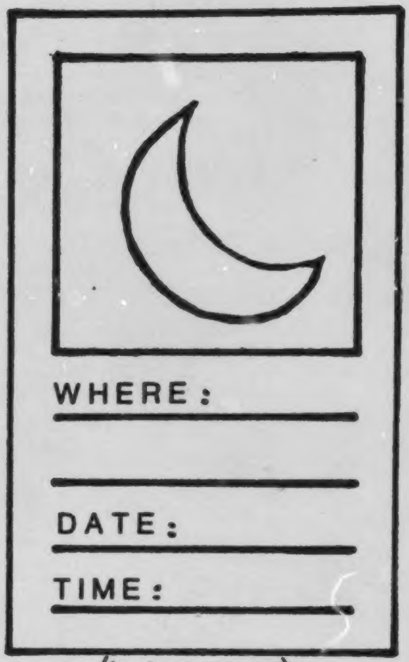
Activity III: Moon-Struck

Materials

- Worksheet on which students can record moon observations (optional).

Sample Worksheet



(Index card)

Procedure

This activity should extend for at least one month. Thus, it could precede or follow the visit of a resource person who is vocationally or avocationally interested in astronomy. Preferably, the activity would precede the visit; and, if possible, telescopic viewing of the moon could be arranged with the visit. (Immediately after a full moon the moon is visible during the early school day.)

Students should gather and record observations of the moon once each day for at least a month. Observations can be made whenever the moon is visible. Observations can begin anytime, but it may be easiest to have students start when they can see a new moon in the southwestern sky about 7:00 p.m. (after dinner and before bedtime). Many calendars show dates of the moon's phases. Each observation should include (1) a sketch of the shape of the moon, (2) the location of the moon when observed (e.g., in southwest, close to horizon), and (3) the time and date of the observation. Try to arrange for a series of observations to be made each two hours on one day of the month. Preferably observations could be made at the time of a new moon, half moon, and full moon. Parent volunteers may be secured, or you could supply the data for those evenings.

After the observations have been made, the students can glue or staple them in chronological order on butcher paper or similar paper. Ask them to look for patterns in their observations. Did the shape change in any regular way during the month? Did the shape change during one day? Did the location change during one evening? Did the location at a particular time, say 7 p.m., change throughout the month? (To answer this question, student must have a series of observatons made at the same time each day.) Where was the sun relative to the moon each day?

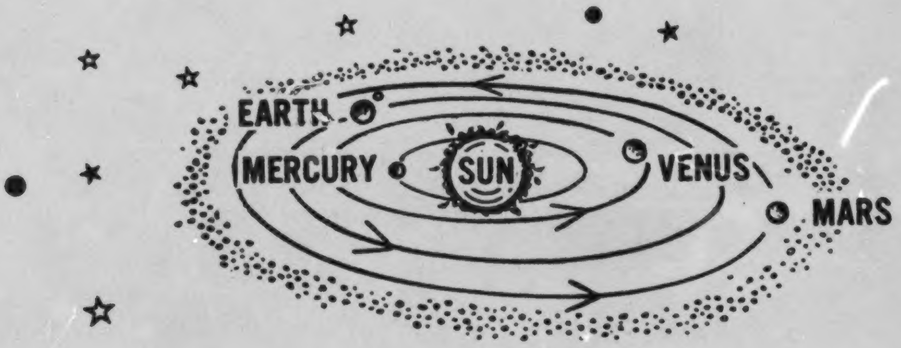
The preceding questions ask for only a reporting of the data. Next you can ask questions which are aimed at explanation. Can you explain your observations that the moon moved westward during one night? Is this similar to the sun's movement? Is this similar to the stars' movement? If the earth rotates, might that explain these observations? In which direction is the earth rotating?

Can you explain the observations that the moon was observed further eastward on succeeding days when observed at the same time? Could we also explain these observations in terms of the earth's rotation? Could we explain these observations by assuming that the moon is revolving around the earth?

Can you explain the change in shape of the moon on succeeding nights? Think about where the sun was relative to the moon as you made the observations.

Can you explain why the same side of the moon is always facing us? Must the moon be rotating as well as revolving around the earth? (See "Women and Graphs" in *Figures Don't Lie* for an illustration that helps explain the moon's making one rotation per revolution).

Figuring out the moon's, earth's, and sun's relative movement from these observations is possible but takes time. The resource person can probably be only partially involved with this process which should be completed by the teacher. For example, resource people could limit themselves to helping students explain the moon's eastward movement (due to its revolution around the earth.)



Extension Activity 1: Nighttime Sky

Materials:

- Copies of "Sky Calendar" and "Evening Sky" (which appear in each issue of Science and Children, a magazine for teachers available from the National Science Teachers Association, 1742 Connecticut Avenue, N.W., Washington, D.C. 20009).

Procedure:

Monthly throughout the school year, Science and Children publishes a lovely map of the nighttime sky accompanied by observations that can be made each day. With the exception of planetary and lunar movement, old issues can be consulted (see school or university library), but it is best to have information also about the planets and moon.

Some students can get hooked on these observations. For quite a few, this may be a new experience. An evening program with resource people, students, and parents could begin by the resource people talking about their vocational or avocational interest in astronomy and conclude with some star gazing.

Career Information

Half of America's 76,000 commercial pilots work for commercial airlines; and the rest work as flight instructors, crop dusters, gas pipeline inspectors, and pilots for air taxis or businesses. Depending on the type of the plane being flown and the type of conditions in which the flying is done, varying levels of licenses are required. Training for these licenses can be acquired in the military, in private flying schools, or sometimes on the job. A high school education is required, but preference is given in the more attractive jobs to people with two or even four years of college.

Related Activities:

Balloons and Gases, Daytime Astronomy, Gases and Airs, and Where Is the Moon? Published by McGraw-Hill Book Company, 1221 Avenue of the Americas, New York, New York 10020.
These teacher's guides deal with behavior of gases and with astronomy.

Mander, Jerry, Dippel, George, and Gossage, Howard. The Great International Airplane Book. New York: Simon & Schuster, 1967.

COMETS Profiles:

Margaret Drake: Mechanical Engineer,
Donna Geisler: Engineer,
Mary McGhee: Sanitary Engineer,
Marylee Southard: Chemical Engineer,
Marcia Turner: Architectural Engineer.

The stories of these five women provide a mosaic picture of engineers which relates to the physical science careers highlighted in this module.

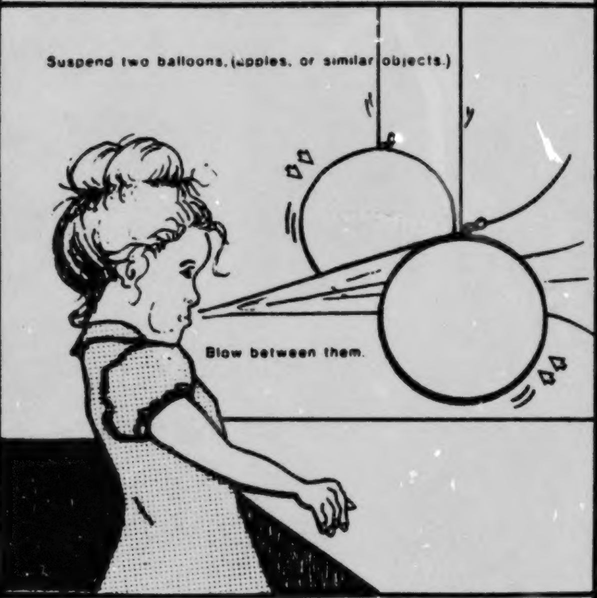
For More Career Information Write:

American Institute of Aeronautics and Astronautics, 1290 Avenue of the Americas, New York, New York 10019.

Education Office, American Astronomical Society, University of Delaware, Newark, Delaware 19711.

Public Relations Department, Air Transport Association of America, 2709 New York Avenue, N.W., Washington, D.C. 20006.

COMETS Challenge Cards



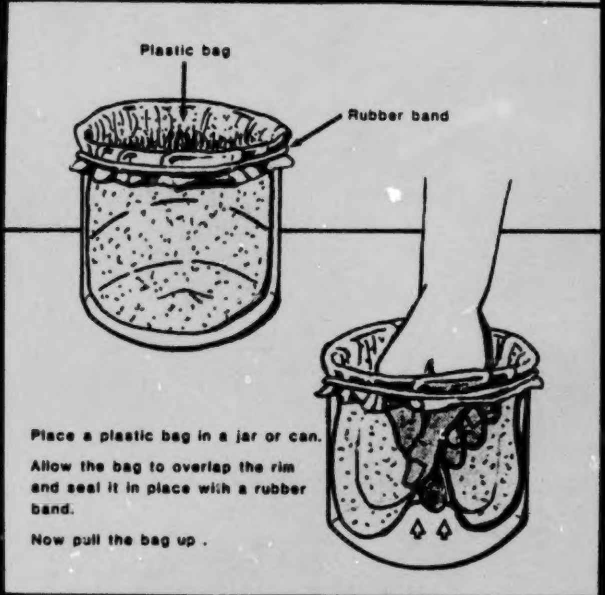
Suspend two balloons. (apples, or similar objects.)

Blow between them.

Through the Air

What makes the balloons move as they do?

COMETS Challenge Cards



Place a plastic bag in a jar or can.

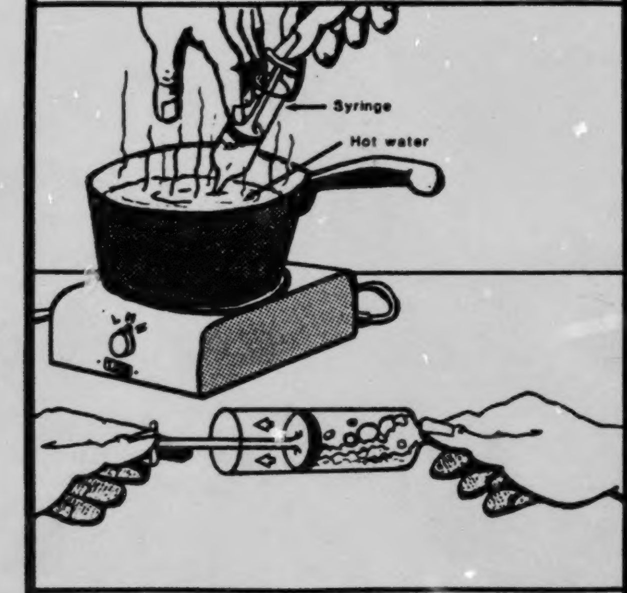
Allow the bag to overlap the rim and seal it in place with a rubber band.

Now pull the bag up .

Through the Air

Why is it difficult to remove the bag ?

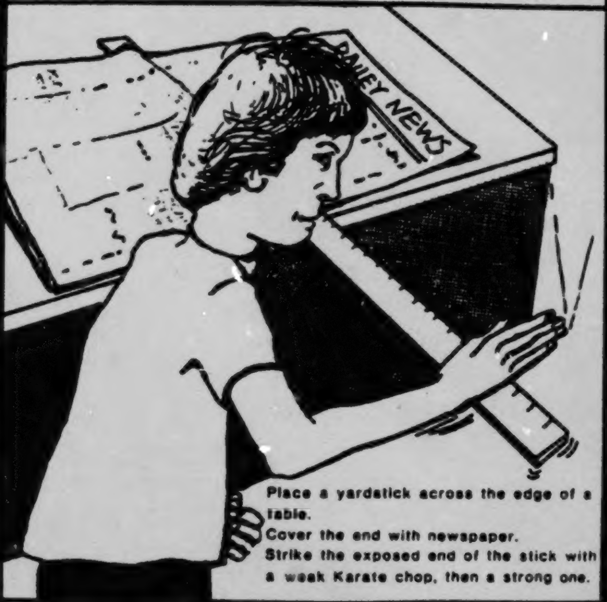
COMETS Challenge Cards



Through the Air

What makes the water boil when its temperature is below 100°C (212°F)?

COMETS Challenge Cards



Place a yardstick across the edge of a table.

Cover the end with newspaper.

Strike the exposed end of the stick with a weak Karate chop, then a strong one.

Through the Air

Why were you able to break the stick?

TOPICS

Health
Human Body
Chemistry

Body Detectives

RESOURCE PEOPLE

Medical Technologist
Other Health Careers
Chemist

THIS MODULE

Activity I

In "Unseen Chemicals" students investigate the properties of red cabbage juice, an acid-base indicator, and discover its remarkable ability to change color in the presence of various substances. Subsequently, students can do detective work with red cabbage juice to find out whether an acid or base is hidden in an unknown liquid. Advance preparation is needed, but it is not too difficult. The length of the activity varies, depending on use of extension activities, but no less than 20 minutes of classroom time is required. Necessary equipment is simple; and it's best if all pairs of students have their own equipment. The development of radioimmunoassey by Nobel laureate, Dr. Rosalind Yalow, relates well to this activity (see "Women and Body Detectives"). Fits well in health unit to demonstrate analogous procedures used by medical technologists to detect the body's condition. Chemists could relate "Unseen Chemicals" to their own testing procedures, which use the same concepts, but may be quite divorced from medical applications.

Activity II

"Sugar Present?" is a particularly appropriate, brief activity to use when a medical technologist visits the classroom. Urine is tested for sugar concentration as an indicator of the body's functioning. Simple equipment. Brief activity. Little advance preparation. Can be done prior to or following "Unseen Chemicals" or can be used alone. Fits well in unit on health, especially when studying endocrine glands and the body's regulation of its own activities. Yalow's work with radioimmunoassey can be related to this activity.

Activity III

"Spare Parts" allows health career people to point out the structure and functions of organs most related to their careers. They can tell how indirect information about the organ is obtained without dissecting the patient. For example, an optician could point out parts of a cow's eye and show how the ophthalmoscope is used. In some cases the resource person can supply materials for the demonstration; but otherwise access to organs through a butcher or meat market would be necessary. Times vary depending on students' interest and detail of the demonstration. Fits well in unit on body parts and functions. Relate contributions of Dr. Florence Sabin in improving public health and in understanding the lymphatic system.

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RELATED MODULES

Body Detectives is intended for health career people to show how they collect indirect evidence to figure out how the body is performing. Some resource people, such as medical technologists, deal primarily with carrying out tests, such as blood chemistry. Other resource people, such as a physician's associate, are concerned with both diagnosis and treatment, but still must understand and be involved in testing. Veterinarians and other animal career people perform identical functions with animals and therefore must possess analogous knowledge and skills. This module's "Unseen Chemicals" would also be appropriate for chemists who apply chemical tests in many diverse ways.

Bones and Balance

Students assemble a skeleton to study its form and function.

Fit N' Trim

Pulse rates are measured to determine physical fitness. The Apgar Test, developed by Dr. Virginia Apgar (See "Women and Medicine"), provides speedy information about a newborn's health and could be related as another example of body detective work.

Healing Techniques

Electrocardiograms or similar printouts are studied to determine the body's activity.

Product Improvement

Whereas Body Detectives emphasizes testing, Product Improvement emphasizes the application of chemical knowledge.

WHERE TO FIND RESOURCE PERSON

Since many people are involved in health careers, your students' parents are a likely source. Contact personal physician, dentist, and/or other health workers. Use local medical society or public health agency. Military establishments often maintain their own health facilities. Former students, now majoring in a life or chemical field at a university, would be a good resource, since topics in this module are probably part of their coursework. Consult yellow pages under veterinarian, optician, health agencies, medical laboratory, dentist, or physician.

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Women and Body Detectives

Materials in amounts as minute as one trillionth of a gram (.000000000001 g)[1] may significantly affect how the body works. However, the detection of such very small amounts of hormones and other chemicals in the body has been possible only in the last 20 years because of the pioneering work of Dr. Rosalind Yalow and her colleagues in development of radioimmunoassay, RIA. Prior to the development of RIA, the presence or absence of these materials was thought to be inconsequential. It's interesting to note this example of "out of sight, out of mind." Until Yalow's RIA technique became available to diagnosticians and researchers, the effects of so-called "trace materials" were largely ignored, since they couldn't be measured. For her work, Rosalind Yalow received the 1977 Nobel Prize in Medicine.

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*How big is one trillionth of a gram? Good question. It's called a picogram, pg; but how can it be visualized? First, think of cigarette ads which talk about milligrams, mg, of tar and nicotine. They make a mg sound small; and it is. A drop of water weighs 50 mg. But a mg is one billion times larger than a pg! (Actually, "weighs" is incorrect; we should say "masses," but "weighs" is sufficient for our purpose here.)

Look at a picogram another way. Finding a picogram in a drop of blood is like finding a raisin in a circular swimming pool that's chest deep in water and nearly four football fields in diameter. Good grief! How could we find the raisin? Let's assume that to be certain we found the raisin, we'd have to assign one person to search a volume of water in this pool 3 feet by 3 feet by chest deep (about 50 cubic feet). To cover the whole pool, we'd need 10,000 people to do the searching! Or let's assume that one person could each day search 50 cubic feet of water. Covering the pool at that rate would take a person over 27 years . . . . . with no vacation.

Here's another way to look at a picogram. This spot is about 1 mm on a side □. If this spot were located on a piece of paper about ten football fields in area, then finding that spot on the paper would be like finding one picogram in a drop of blood.

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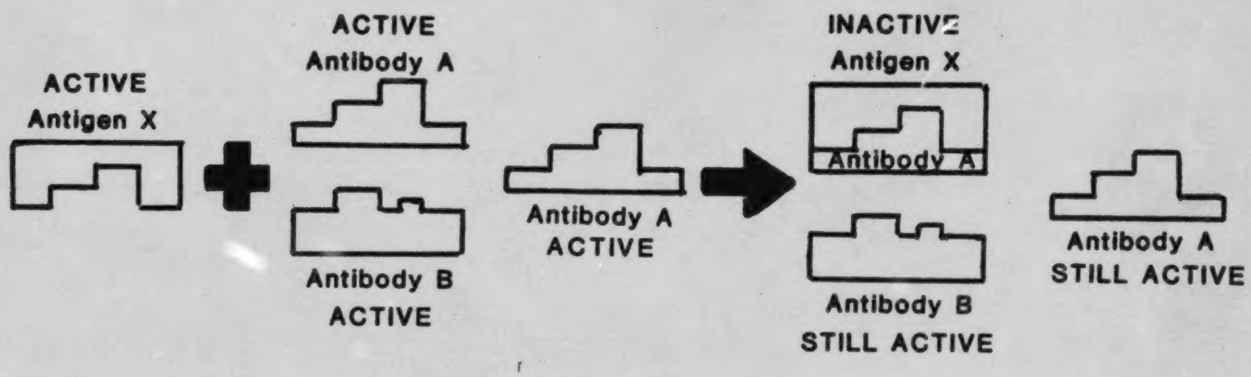
Some students may be satisfied to simply know that Yalow developed a means to measure small amounts of materials which affect the body's health. For them you can skip to the subsection, "RIA's Applications." Other students, especially those more adept in math, may be interested in a further explanation of RIA as an application of math and science to medicine.

How RIA Works:

Breaking the word, radioimmunoassay, down into its three constituent parts helps explain Yalow's technique. "Assay" refers to the fact that RIA is used to quantify how much of a particular material is present in a particular sample, say a blood sample. (From watching westerns on TV, your students may be familiar with gold prospectors who took their ore to the assay office to determine how much gold was contained in the ore.)

The "immuno" part of RIA comes from immunology, the study of how the body fights off foreign invaders, such as bacteria. In immunology, the foreign material is called an antigen and the material produced by the body to combat the antigen is called an antibody. It is assumed that for each antigen there is a specific antibody which will render the antigen inactive. Often the antibody clumps together with the antigen; and it's this type of interaction that's taken advantage of in RIA. An antigen is frequently, but not always, a protein. The antigen could be a part of a bacterium or virus, a chemical secretion of another individual, or a tissue transplant. In the diagram antigen X specifically combines with antibody A, but not antibody B. One unit each of antibody and antigen will combine; any excess of antigen or antibody will remain free and active.



Finally, the "radio" part of RIA refers to the use of radioactive materials. The amount of a radioactive material can be measured by counting how much radioactivity the material exhibits. More radioactivity means more material; less means less. Your students may be familiar with Geiger Counters which are used to measure amounts of radioactivity.

The trick now is to put all this together; and that's what Yalow did. (While reading about RIA, refer to the diagram following page 6 which can be made into an overhead.) Three ingredients are mixed:

(1) An unknown amount of some substance (antigen). This is the material which is to be quantified.

(2) A known amount of the antibody for that substance.

(3) A known amount of the antigen tagged with a radioactive isotope. (One could tell how much radioactive antigen is added by measuring its radioactivity.)

The antibody clumps together with both the radioactive and normal antigen until all the antibody is used up. Thus, some uncombined, radioactive and nonradioactive, antigen is left over and it can be separated from the clumped antigen. The amount of leftover, uncombined radioactive antigen can be found by measuring its radioactivity.

Now there's a little math, which can be explained by example and reference to the diagram. Let's assume that originally 300 units of antibody A were mixed with 300 units of radioactive antigen X plus an unknown amount of the nonradioactive antigen X. (We can see how much unknown is in the diagram, but that's not known to the experimenter.) We allow the antigen-antibody clumping to take place and separate out the radioactive antigen X that remains. Our measurements with a Geiger Counter show that there's 200 units of leftover radioactive antigen X. By subtraction we calculate that 100 units of radioactive antigen clumped with the antibody.

300 units of radioactive antigen X originally mixed.
- 200 units of radioactive antigen X which were left over.
100 units of radioactive antigen X clumped with the antibody.

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Since all the antibody was combined and since 100 units of antibody combined with radioactive antigen, then by substraction (300 - 100) there must have been 200 units of nonradioactive (unknown) antigen combined with the antibody.

We now use a ratio. Note that twice as much nonradioactive antigen X (200 units) as radioactive antigen X (100 units) combined with the antibody A. Therefore, there must have originally been twice as much unknown antigen X as known, radioactive antigen X.

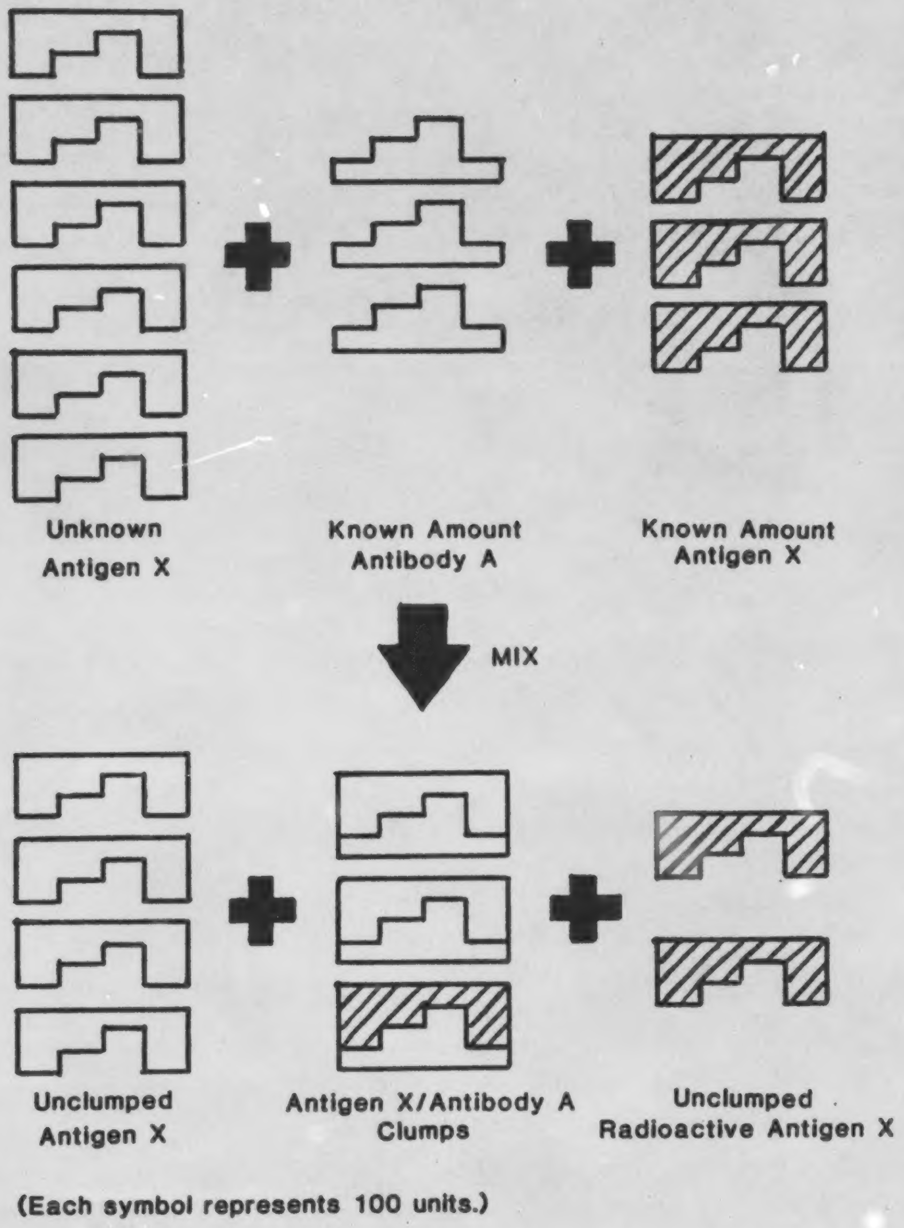
$$\frac{\text{200 units nonradioactive antigen X}}{\text{100 units radioactive antigen X}} = \frac{\text{2 units}}{\text{1 unit}}$$

Since we know that we originally added 300 units of radioactive antigen X, there must have been 600 units of unknown, nonradioactive antigen X (2 x 300 units).

RIA's Applications:

The uses of RIA both as a diagnostic tool and as a research procedure are legion. For example, when trying to unravel the mechanism whereby hormones produced in the pituitary gland regulate activity in, for example, the ovary, microscopic amounts of these pituitary hormones must and can be detected. RIA has also been used to detect hepatitis virus in blood earmarked for transfusion, thus preventing the inadvertent spread of the disease. In criminology work, RIA can be used to determine the source of blood, perhaps under a victim's fingernails, thus potentially linking the offender with the crime.

Rosalind Yalow's development of radioimmunoassay can be related to either "Unseen Chemicals" or "Sugar Present." Whereas your students use color changes to detect the presence of chemicals in a solution or in urine, Yalow applied her knowledge of physics and medicine to find and quantify unknown chemicals using radioactivity. For more information about Rosalind Yalow and her work, refer the interested student to Women Pioneers of Science by Louis Haber (New York: Harcourt Brace Jovanovich, 1979).


Unknown Antigen X
Known Amount Antibody A
Known Amount Antigen X
MIX
Unclumped Antigen X
Antigen X/Antibody A Clumps
Unclumped Radioactive Antigen X
(Each symbol represents 100 units.)

Rosalind Yalow's Radioimmunoassey Technique, RIA

Florence Sabin

Although Rosalind Yalow won her Nobel Prize during her lifetime (the Nobel is always awarded to a living person), Dr. Florence Sabin received one of her greatest honors posthumously. Each state is allowed to recognize one, and only one, of its citizens in the Statuary Hall in the Capitol Building in Washington, D.C. The state of Colorado chose to so honor Florence Sabin primarily for her public health work which she began when she was over 70 years old and after a long and distinguished career as a medical researcher and teacher.

During her outstanding medical schooling, from which she emerged in 1900 as Johns Hopkins University's first woman M.D., Florence Sabin completed a detailed study of the brain; and then she devoted herself to unraveling the mysteries of the lymphatic system and later, blood cells.

Her research work was widely recognized; but it was only after her retirement that she completed the work for which her state honored her. She was appointed in 1944 to head Colorado's governor's public health committee. Due to her vigorous and thorough work, laws were passed and procedures were modified, resulting in the lowering of Colorado's death rate from one of the highest to one of the lowest in the country. At 78 she became head of Denver's health department; and during her three year term she eradicated the city's rat problem, improved sewage disposal, set up free x-ray locations, and ensured the sale of pure milk throughout the city.

While studying "Spare Parts," you or the resource person could relate the story of Dr. Florence Sabin, who devoted most of a lifetime to the study of the body and then capped off an already full life with outstanding public service. Your students may want to find out more about Dr. Sabin by reading Proving the Unknown: The Story of Dr. Florence Sabin by Mary Kay Phelan (New York: Crowell, 1969) or the shorter and easier to read Women and Science by Valjean McLenighan (Milwaukee: Raintree Publishers, 1979).

Activity I: Unseen Chemicals

Materials for the Whole Class:

- One quart red cabbage juice.
- One quart dilute vinegar.
- One quart dilute household ammonia.
- Newspaper.

Materials for Each Pair of Students:

- Five plastic pill cups or similar small containers with three tablespoons plain red cabbage juice (RCJ) in one, two tablespoons dilute vinegar in the second, two tablespoons dilute ammonia in a third, tap water to flush droppers in the fourth, and nothing in the fifth (it will be used for testing). All volumes are approximate.
- One medicine dropper. (A drinking straw can be substituted but is less preferable. Cover and uncover one end of straw to make it work like a dropper.)
- Cardboard tray makes handling the pill cups simpler (optional).

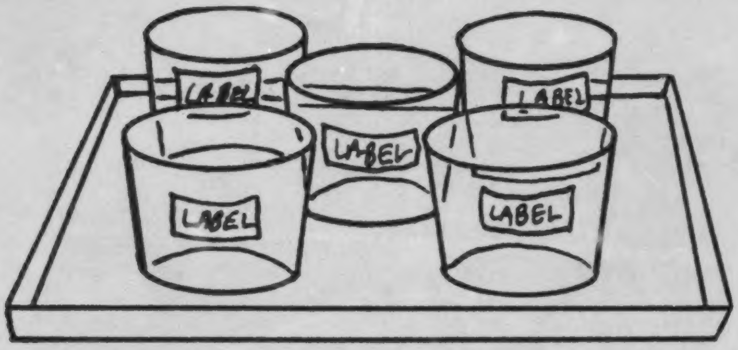
Preparation of Materials Before Class:

Red cabbage juice, RCJ, can be made by chopping and boiling a quarter head of red cabbage in 1-2 quarts water until the cabbage turns white (about 5-10 minutes). Strain out the cabbage and collect the juice, which should be purple. Refrigerate the juice in a covered jar until used, since the juice contains lots of sugar and is a good nutrient for growing microorganisms. RCJ can be diluted to stretch over a larger class as long as the color of the juice can be easily seen.

Dilute one pint vinegar with one pint tap water. (The exact concentration of vinegar is not too important. Dilution is suggested only as a means to save money.)

Similarly, one pint of household ammonia can be diluted with one pint water. In these weak concentrations there's little chance of harm from these chemicals; but as always, students should be encouraged to use care. Spills should be cleaned up. If any chemical gets on the skin, flush the area with running water. Dispose of chemicals down the drain with running water to further reduce the concentration.

Label the contents of each container.



Procedure:

Give each pair of students five pill cups and ask them to mark the contents of each cup in some way. The drawing shows one method.

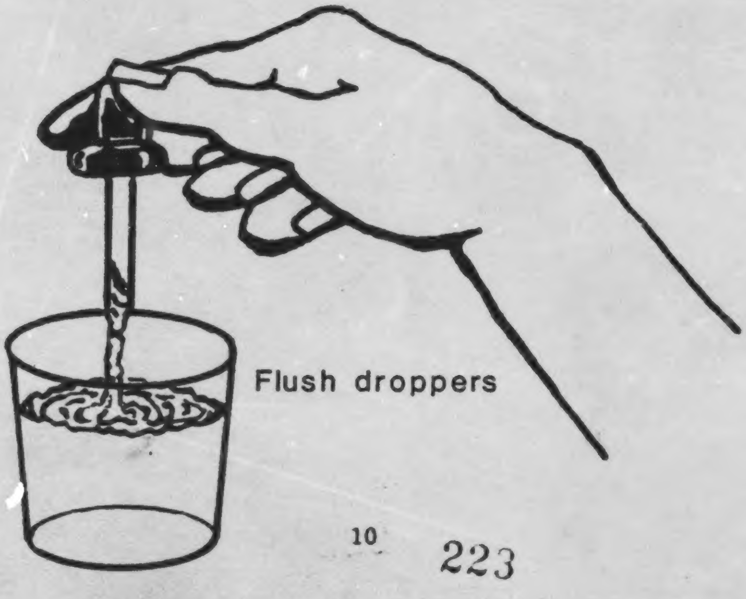
Instruct students to place about 15 drops RCJ in their empty testing cup. Flush droppers after each use by drawing in and ejecting tap water two or three times.

Add dilute vinegar one drop at a time to the RCJ in the testing cup. After each drop is added, pick up the cup and gently swirl the contents. Observe any color change. Do not use the dropper as a stirrer.

Continue adding drops and swirling until a permanent color change is noted. Vinegar, an acid, changes RCJ from purple to pink.

If sufficient pill cups are available, the cup with the RCJ and vinegar should be saved to make comparisons later; and fresh empty cups should be used for each test. It insufficient cups are available, then the test cup should be cleaned before preceding.

Flush droppers, and then to an empty test cup again add about 15 drops of the original purple RCJ. Flush droppers.



Add dilute ammonia dropwise; swirl contents; and observe color change. Ammonia, a base, turns RCJ from purple to blue and then to green.

Challenge students to turn some fresh RCJ from purple to pink to green to pink to green to . . . (the pink to green change can be accomplished by adding ammonia; and the reverse color change can be accomplished by adding vinegar. Note the RCJ reveals the relative concentration of the vinegar and ammonia and not the presence of either one. For example, when the vinegar concentration supercedes the ammonia concentration, the solution becomes pink, even though the ammonia is still present.)

Relate how Rosalind Yalow developed a test which, instead of color change, used radioactivity to determine the presence of chemicals in a sample.

More Information

Red cabbage juice is one of a large group of chemicals which change colors depending on the pH of the solution to which they are added. The chemicals which change colors are called indicators, since they can "indicate" the pH of a solution. (pH refers to how acidic or basic a solution is. pH is indicated by a number from 1 to 14 with 1-6 indicating acidic (lower numbers being more strongly acidic), 8-14 indicating basic (higher numbers being more strongly basic), and 7 indicating neutral.)

Different indicators change colors at different pH's. One indicator may be one color above pH 7 and a different color below pH 7; a second may change colors at pH 4; and a third at pH 10. By using a series of indicators either separately or as a mixture, one can very precisely pinpoint the pH of a solution.

Why's it important to know pH? The answers to that question are many; but in general, pH affects what and how a chemical reaction can take place. In turn, since life is based on many chemical reactions being able to take place, all life depends on being able to maintain a certain, optimal pH within and outside the organism. For example, our digestive enzymes work best at a certain pH; and our body is set up to regulate and maintain that pH within the digestive tract. If our digestive tract pH gets too far away from the optimal point, as happens sometimes when we eat too much of the wrong thing, our body reacts, often in a distressing way which we may call "heartburn." In that case we can take some baking soda or other antacid (all bases) to get our digestive tract pH back in line.

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Extension Activity 1: Testing an Unknown

Materials for the Whole Class:

- One quart red cabbage juice.
- One quart dilute lemon juice, marked "X". Prepare by adding one pint water to one pint lemon juice.
- One quart water to which three scoops baking soda have been added, marked "Q".
- One quart water to which a scoop of cream of tarter has been added, marked "T".
- Newspaper.

Materials for Each Pair of Students:

- Five pill cups with 3 tablespoons of RCJ in one, 2 tablespoons of "X" in the second and "Q" in the third, water in the fourth, and nothing in the fifth.
- Medicine dropper.
- Cardboard tray (optional).
- One pill cup with 2 tablespoons "T" to be given to students later.

Procedure:

Ask students how they could use RCJ to find out whether "X" is more like vinegar or more like ammonia. They may be confused about whether they should add "X" to the RCJ or to vinegar or to ammonia or to some combination of the three. However, after discussing the problem, they should figure out that they should add 15 drops of RCJ to the test pill cup. Then after flushing their droppers, they should add "X" dropwise, swirl, and observe any color change. After they have figured out how to test their unknown solutions, pass out the materials to each pair of students. (Since lemon juice is an acid, it will turn RCJ pink; and students should be able to figure out that vinegar and lemon juice share a common property. You can tell the students that shared property, turns RCJ pink, indicates both are called acids).

Ask them to test "Q" as they did "X". (Since "Q" is a base, like ammonia, it will turn green.)

Finally, ask them to test "T" to determine whether this unknown chemical is an acid or base. (Cream of tarter, an acid, turns RCJ pink.)

The most common indicator is litmus paper, a paper impregnated with litmus which turns blue when the solution is basic and red, when acidic. Other examples of indicators are phenolphthalene, methyl orange, and brom thymol blue (which your students may know as BTB, if they have been exposed to SCIS, Science Curriculum Improvement Study, which uses BTB, but does not include any explanation of what BTB is).

Extension Activity 2: Testing Strength of an Unknown

Materials for the Whole Class:

- One quart red cabbage juice.
- One quart each of straight household ammonia, dilute ammonia, and very dilute ammonia.
- One quart each of straight vinegar, dilute vinegar, and very dilute vinegar (optional).
- Newspaper.

Materials for Each Pair of Students:

- Eight pill cups with 3 tablespoons of RCJ in one, 2 tablespoons each of straight household ammonia, dilute ammonia, and very dilute ammonia in the second, third, and fourth cups, water in the fifth, and nothing in the sixth, seventh, and eighth cups. Amounts are approximate.
- Medicine dropper.
- Cardboard tray (optional).

Preparation of Materials Before Class:

Straight household ammonia is the household ammonia as purchased at a grocery store. Dilute ammonia is prepared by combining one pint straight household ammonia and one pint tap water. Very dilute ammonia is prepared by combining one pint straight household ammonia to four pints tap water. Mark each solution. (The vinegar solutions, if used, are prepared in the same way.) Dilutions are approximate.

Procedure:

Ask students to count the number of drops it takes for straight ammonia to turn RCJ green. Save this green solution for later comparison.

Similarly have students count the number of drops of dilute ammonia and very dilute ammonia needed to turn RCJ to the shade of green obtained by adding straight household ammonia. (They should find that the more dilute the

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ammonia the more drops needed to obtain the green color. If they find that dilute household ammonia changes the color as rapidly as straight household ammonia, then dilute the household ammonia even more.)

If desired, the same procedure could be followed with vinegar solutions.

From these observations students should be able to conclude that the RCJ, or other indicators, could be used to figure out the relative concentrations of acid or base in a particular solution. In fact, your students have begun doing titrations, a technique used in quantitative analysis, a branch of chemistry which is devoted to the precise measurement of the amounts of any given material present in any given sample. Titration is one means to measure precisely amounts of unknown material in a solution. If not done previously, relate here Dr. Yalow's work with radioimmunoassay which is a very precise and sensative quantitative analysis technique.

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Activity II: Sugar Present?

Materials:

- Commercially available (at drug store) urine sugar test tape such as Clinitest® or Acetest®.
- Urine sample. (Resource people, if they routinely do urinalysis, may be able to supply urine samples from diabetics and "normals" containing varying amounts of sugar. If this is possible, it is preferable.)

Procedure:

If this activity follows "Unseen Chemicals" (Activity I), then remind the students how the color change in red cabbage juice indicated whether the solution was acidic or basic. If "Unseen Chemicals" was not done, then explain that certain chemicals change colors under different conditions. In either case, proceed to tell the students that the color change of some chemical can be used to detect how much sugar is present in a solution. Specifically, this test can be done on urine in order to find out how much sugar the body is excreting.

Perform the test according to directions included with the test tape. Explain the results; that is, whatever color was obtained indicates a certain sugar concentration. Probably this activity should be done as a demonstration.

It's valuable to know how much sugar is in the urine because this information indicates how well the body is using sugar, its energy source. If the body does not properly use sugar, a condition called diabetes, excess sugar builds up in the blood, exists. The excess sugar is removed by the kidneys and is excreted in the urine.

Blood sugar level is regulated by insulin, which the body normally produces in order to maintain sugar at the optimal level. If the body does not properly maintain the correct level of insulin, the proper blood sugar level is not maintained; and in turn the body's energy use gets out of line, leading to several possible problems (e.g., fainting). The diabetic person must self regulate blood sugar through diet and/or the use of insulin. To help diabetic people and their physicians know what their blood sugar level is, they use the commercial test tape to measure sugar in their urine. Too much urine sugar indicates reduced sugar intake and/or more insulin is needed; too little means reduce the insulin and/or ingest some sugar. (Note that sugar is the form in which the body usually uses its energy. The energy food may originally have been consumed not only as sugar (e.g., in an apple or candy bar), but also as carbohydrate.)

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Activity III: Spare Parts

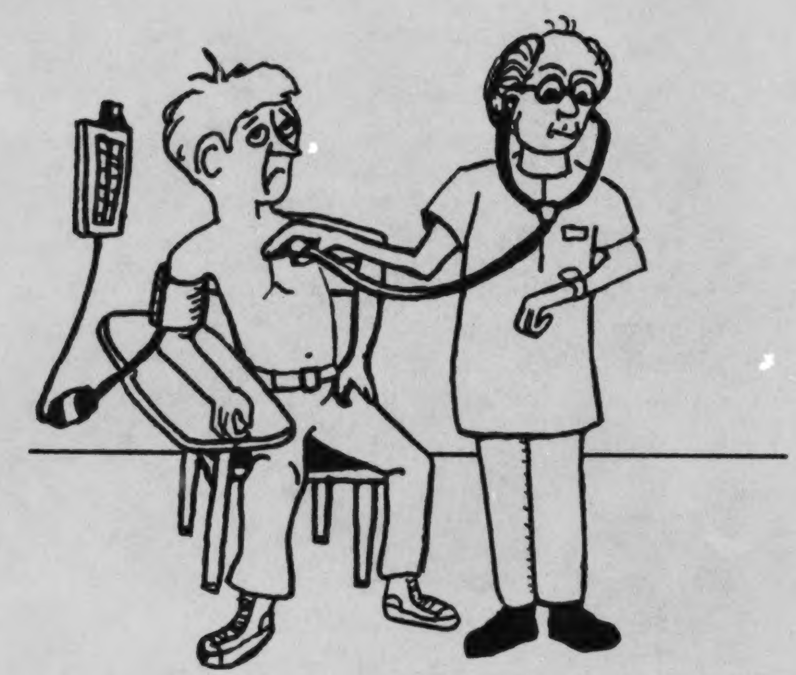
Materials:

- Organ or body part (such as kidney, heart, liver, or eye) from freshly slaughtered animal obtained from a butcher, grocery store (e.g., chicken leg), or in a preserved form from a biology laboratory.
- Medical instruments such as stethoscope, otoscope, or ophthalmoscope to be provided by the resource person (preferable, but optional).

Procedure:

Health workers, including both the diagnoticians and providers of treatment, have become specialists. Resource people should dissect organs, or body parts, related to their specialty and demonstrate the instruments and/or techniques they use to observe those organs or body parts. The length of this demonstration can be quite variable. Since most specialists first of all are generalists, they may use "spare parts" from outside their specialty. (A similar activity, "Squiggly Lines," is included in Healing Techniques, in which the resource person brings, for example, an EKG printout and tells how it is obtained and interpreted.) This chart shows some examples of health career specialties and their related body parts and instruments or techniques.

Specialty	Body Part	Instrument/Technique
Optician/Ophthalmologist	Eye	Ophthalmoscope
Inhalation Therapist	Lung	Stethoscope
Registered Nurse	Heart	Sphygmometer (measures blood pressure)
Physical Therapist	Leg	Manipulation of muscles and skeleton
Internist	Liver	Palpation



Prior to or subsequent to the resource person's visit, you may choose to have students individually or in small groups do the dissection. While individual work is stimulating, there are problems -- some are repulsed; obtaining sufficient organs and dissection tools is increasingly difficult; dissection for the neophyte may become chopping and slicing with little learning occuring. Caution: Because of the danger of infection, use only properly preserved specimens or freshly slaughtered animal material that is disease-free. Do not use road-killed animals or any other suspect material. However, despite potential problems, the individual study of animal parts can pay off in knowledge and a desire to learn more about the material being investigated.

Career Information

In 1978 over 4.4 million people worked in health careers. This field is expected to grow at a higher than average rate in the 1980's as the population grows and ages, new technological advances are made, and prepaid public or private medical insurance programs expand (assuming they do indeed expand). By far the largest health career area, nursing occupations, constituted 58% of health workers in 1978; and of these 1,050,000 were R.N.'s (that's nearly one out of every four health workers). Nearly two-thirds of expected health career job openings in the 1980's will occur in nursing occupations. In 1978 health practitioners, including such career areas as physician and veterinarian, made up 12% of health occupations; 11% were in health technologies (e.g., x-ray technician); 4% were in therapy (e.g., occupational therapy) and 15% were in other health careers (e.g., pharmacist).

This listing of health careers and the number of practitioners taken from the 1980 Occupational Outlook Handbook demonstrates the wide range of health careers. Point out to students that they come in contact with only a fraction of health career workers; there are many others who work behind the scenes or primarily with adult patients. With such a large variety of careers from which to choose, health occupations are marked by great diversity in training, required characteristics, working conditions, earnings, and other job characteristics. Refer students to the Exploring Careers chapter on "Health Occupations" to introduce these careers.

People in Health Careers

Practitioners

Dentist (120,000)
Dental Assistant (150,000)
Dental Hygientist (35,000)
Dental Lab Technician (47,000)
Chiropractor (18,000)
Optometrist (21,000)
Osteopath (17,000)
Physician (385,000)
Podiatrist (8,100)
Veterinarian (33,500)

Technologist

EKG Technician (20,000)
EEG Technician (7,000)
Emergency Technician (115,000)
Medical Laboratory Worker (210,000)
Medical Records Technician (50,000)
Operating Room Technician (35,000)
Optometric Assistant (15,000)
X-ray Technologist (100,000)
Respiratory Therapy Worker (50,000)

Nursing

Registered Nurse (1,050,000)
Licensed Practical Nurse (518,000)
Aides and Orderlies (1,040,000)

Therapy

Occupational Therapist (15,000)
Occupational Therapist Asst. (10,000)
Physical Therapist (30,000)
Physical Therapist Asst. (12,500)
Speech Pathologist (32,000)

Other Health Careers

Dietician (35,000)
Dispensing Optician (17,500)
Health Administrator (180,000)
Medical Records Administrator (12,500)
Pharmacist (135,000)

Career Information:

Department of Labor, Bureau of Labor Statistics. Exploring Careers. Bulletin 2001. Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. Order S/N 029-001-02224-7, $10, 1979. Also available as 15 separate chapters. For a set of all 15 separate chapters, order S/N 029-001-02225-7, $12. For the chapter, "Health Occupations," order S/N 029-001-02236-1, $2.

Oleksy, Walter. Careers in the Animal Kingdom. New York: Julian Messner. 1980. Interviews of wide range of people interwoven with career facts and personal insights.

COMETS Profiles:

Joan Brunfeldt: Doctor of Internal Medicine and Marian Washington: Basketball Coach. These two Profiles provide quite varying perspectives on how knowledge of anatomy and physiology are applied in careers.

Other Profiles feature various health career people including a nurse, pharmacist, dietician, dentist, athletic trainer, and physicians in other specialties.

For More Career Information Write:

National League for Nursing, Career Information Services, 10 Columbus Circle, New York, New York 10019.

American Medical Technologists, 710 Higgins Road, Park Ridge, Illinois 60068.

American Society for Medical Technology, 5555 West Loop South, Bellaire, Texas 77401.

American Society of Clinical Pathologists, Board of Registry, P. O. Box 4872, Chicago, Illinois 60680.

International Society for Clinical Laboratory Technology, 818 Olive Street, Suite 918, St. Louis, Missouri 63101.

American Physical Therapy Association, 1156 15th Street, N.W., Washington, D.C. 20005.

See Fit N' Trim for additional references.

Career Oriented Modules to COMETS Explore Topics in Science

TOPICS

Skeleton

Vertebrates

Human Body

Bones and Balance

RESOURCE PEOPLE

Veterinarian

Physical Therapist

Other Health Careers

THIS MODULE

Activity I

In "Bone Detectives" students take fragments of the chicken's sternum, clavicle, and femur and reconstruct these bones in a fashion similar to the work of anthropologists such as Mary Leakey (see "Women Applying Spatial Relations" in Third Dimension). The materials are simple but a good deal of collecting is necessary, if enough bones are to be available for individual student work. This activity would fit well into a study of the skeleton. Different resource people - veterinarians, physicians, osteopaths, podiatrists, chiropractors, physical therapists, anthropologists, and other health career prople - could be used as resource people. The work of Julie Glowacki and Mildred Trotter (see "Women and Bones") could be related here.

Activity II

"Construct a Skeleton" requires students to make a skeleton or a poster display of the bones. Since the activity is so involved, it should precede or follow a resource person's visit; and perhaps only a few students would do the activity. In an extension activity, "Comparative Anatomy," students compare chicken bones with their own. Challenge Cards are available to guide this activity. Again, a great deal of collecting of simple materials is required, and a variety of resource people could be used.

Activity III

"The Human Machine," which fits well in a unit on the human body, requires no special equipment and the activities are brief. Five activities involving the application of physical laws to the functioning of the body are described; but the resource person could chose to use any or all of the two physical concepts illustrated. Any of the aforementioned resource people could be used, but physical therapists and chiropractors, who need to be especially knowledgeable about the structure and function of the skeleton and muscles, would be especially good resource people.

University of Kansas School of Education Department of Curriculum and Instruction

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RELATED MODULES

Bones and Balance is intended primarily for health career people, especially veterinarians, physical therapists, chiropractors, and physicians, and for physical anthropologists. Health career people may be used in any of the following modules.

Pearly Gates

Students learn about teeth and other skills used by dentists.

Body Detectives

Red cabbage juice, an acid-base indicator, is used to illustrate the work of people like medical technologists in studying the body's state of health.

Fit 'N Trim

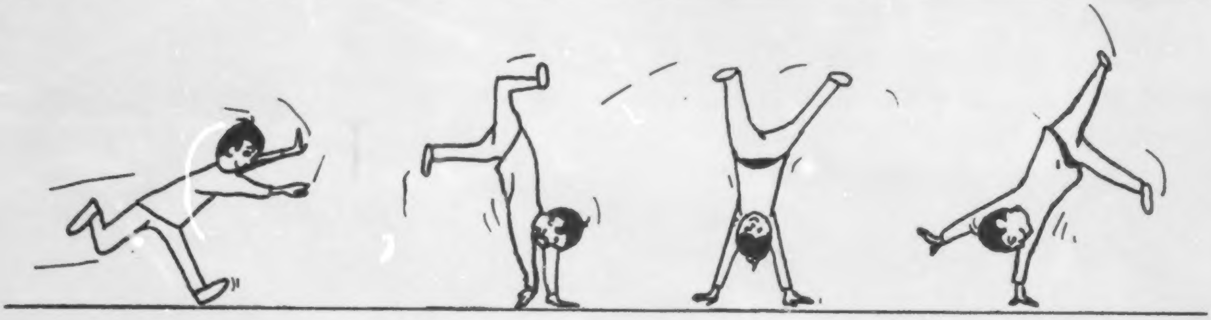
Genetics, physical fitness, and tissue transplants are studied.

Health Helpers

Organs, such as eyes, instruments used in studying these organs, and printed information such as an EKG are used to study functioning of the body.

WHERE TO FIND RESOURCE PEOPLE

Look in the yellow pages for veterinarians, podiatrists, osteopaths, chiropractors, and physicians. Physical therapists usually work in clinics or hospitals, so they should be contacted there. A coroner would be a particularly interesting resource person for this module. Contact them through the police department or look in the yellow pages under government. Contact universities for faculty and students in anatomy, anthropology, or if these departments are available, medicine or physical therapy. A public health clinic or local medical society may provide resource people.



Women and Bones

While veterinarians and physicians mend broken bones, and physical therapists help heal patients with bone problems, anthropologists busy themselves studying bones to learn about the people and animals that produced them. Mary Leakey (see "Women Applying Spatial Relations" in Third Dimension) carefully reconstructed bones from dozens of tiny fragments in order to learn about our prehistoric ancestors. Mildred Trotter, another anthropologist, however, has been more interested in bones of contemporary people.

She extensively studied war casualties and in so doing was able to figure out a way of reliably estimating the overall size of an individual given only the length of the long bones of the arms and legs. The mathematical equation derived by Mildred Trotter is useful not only to academicians interested in estimating the size of people whose skeletal remains were found (say, in a burial mound) but also to forensic scientists interested in determining the identity of a badly decomposed body. Thus, if such remains were found, measurements could be taken of the long bones (femur, humerus, etc., which, of course, remain in tact long after muscles and other tissues decay). These measurements could be plugged into Trotter's equations and the size of the individual determined and joined to other evidence to help identify the body.

Dr. Julie Glowacki has made a very different contribution to our understanding of bones. Working with several surgeons who did the clinical work, Julie Glowacki did the biochemical work which apparently will enable us to grow any needed new bones in the human body. So far, some three dozen people from ages one to 59 have received replacement bones with the most spectacular case being a six year old lad whose badly misshapen skull was reformed into a normal skull.

Heretofore, bone replacement required removal of bone from one part of the body and placement in the new site. This bone graft, if it were not reabsorbed by the body (which happens in one-third to one-half of these operations), would stimulate bone tissue on either side of the bone graft to form new bone tissue. The technique developed by Julie Glowacki and here colleagues does not require the donation of bone from another part of the patient, thus saving one operation. Rather, flakes, chips, or wedges of demineralized bone from a cadaver can be fashioned in place where the new bone is needed. After being put in place, the demineralized bone stimulates the

M

body to transform this demineralized bone into new bone.

This new technique has several advantages. One, there is virtually no reabsorption of the new bone (as compared to 33 to 50 percent reabsorption in the previous technique). Two, a second operation to acquire the bone graft is not needed, so cost and risk are reduced. Third, almost any donor, including cadavers and probably other animals (this is being worked on), can supply the demineralized bone which can be produced in any necessary form - flakes, chips, or wedges. Fourth, the technique promises to be adaptable to any bone needs; the previous technique was limited. Finally, the demineralized bone technique has a faster recovery rate.

The 206 bones of humans (we have about 300 at birth but this number is reduced as bones fuse together) are made of collagen fibers, water, and calcium, phosphorous, and carbonate salts. In this new process, the mineral fraction of the bone is removed; and when the product is put in place, the body begins to produce cartilage, and finally bone is produced.

The applications of this technique seem limitless, although so far the technique has primarily been used on bones, such as the skull, which do not bear weight. Work on weight-bearing bones in humans has only begun. Relate this work of Dr. Julie Glowacki and her Harvard colleagues and Mildred Trotter in Activities I and II when bone is being studied.

Activity I: Bone Detectives

Materials:

- Sternum (breast bone), clavicle (wishbone), and femur (thigh bone), each broken into several pieces and then all pieces mixed together.

Preparation:

The bones should be saved throughout the year from turkey and chicken dinners. Students may bring bones from home; or perhaps a school cafeteria, restaurant, hospital cafeteria, or other source could be found. See "Preparation of Skeleton Material" in Activity II for suggestions about preparing the bones. Partially cleaned bones from several different chickens and turkeys can be stored in the freezer and then all bones finally cleaned together when sufficient bones have been collected. Other sets of pieces from three bones can be made, but the three bones listed under "Materials" were chosen to provide three contrasting and identifiable bones which are available in the whole chicken or turkey purchased at the grocery store.

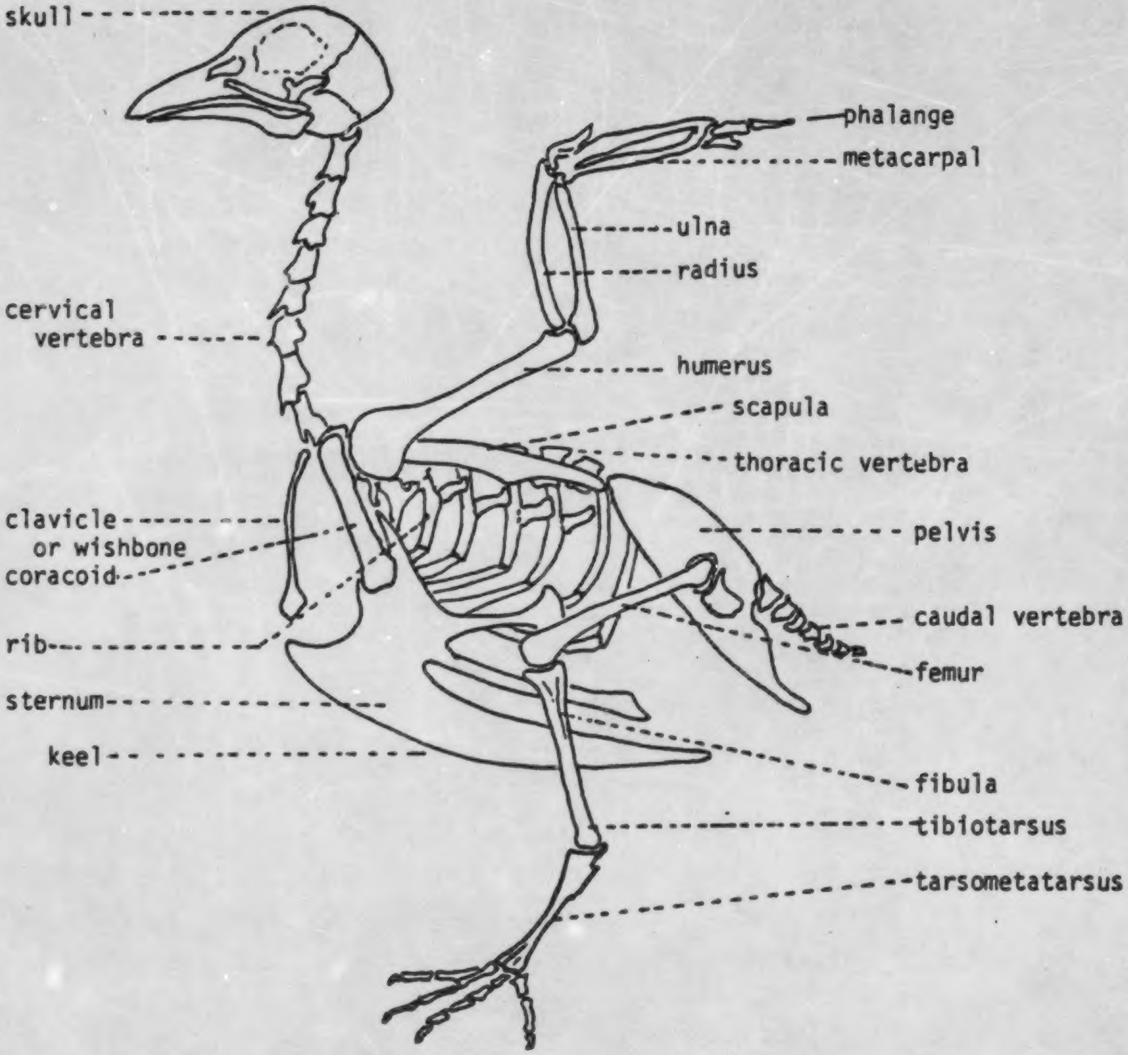
Procedure:

Sufficient bones should be collected so that individuals or small groups of students could do the activity. With small numbers of bone sets, the activity could be done in a learning center or as a demonstration. However, the small size of the bones makes a demonstration impractical. The resource person should give these directions after the bone sets have been distributed.

You have fragments of at least two different bones in your set. You should put the pieces together to reconstruct the original bones. The resource person, depending on their specialty, could embellish the directions by, for instance, having students pretend these are bones found in a burial ground. As finders of these bones, they are trying to figure out what animal was the source of the bones. Then they could conclude what animals were associated with the people buried in those grounds. The work of Mildred Trotter (see "Women and Bones") and Mary Leakey (see "Women Applying Spatial Relations" in Third Dimension) could be related here. Dr. Mary Leakey spent countless hours piecing together bone fragments of human ancestors and other animals found with the prehuman remains in east Africa.

After the students have reconstructed the three bones in each set, have them attempt to identify the source of the bones. The wishbone (clavicle) should provide a key clue for identification.

The resource people could then relate this activity to their own careers. A veterinarian, chiropractor, physician, or physical therapist, for example, could emphasize bone form and function; whereas an anthropologist or coroner could emphasize the detective work in the activity.


skull
phalange
metacarpal
ulna
radius
cervical vertebra
humerus
scapula
thoracic vertebra
clavicle or wishbone
coracoid
pelvis
caudal vertebra
rib
femur
sternum
keel
fibula
tibiotarsus
tarsometatarsus

Chicken Skeleton

Activity II: Construct a Skeleton

Materials:

- Skeleton from chicken, turkey, rabbit, pigeon, or whatever animal is available. (Chickens, turkeys, and rabbits are available; but since they often are young skeletons - so the meat would be more tender - they may disintegrate too easily in preparation. Therefore, wild birds, such as a mature pigeon, may work better, since the bones will be harder; but use larger birds with larger bones. Perhaps a local bird watcher or hunter could supply a cleaned carcass with all internal organs and most meat removed.)
- Poster board (preferably black or other dark color).
- Glue and/or wire.
- A copy of the chicken skeleton diagram on page 6 (optional).
- Paring knife.
- Pot.
- Stove or hot plate.
- Water.
- Soap.
- Old toothbrush.
- Bleach.

Preparation of Skeletal Materials:

If there is no collection of bones available at your school, the local market may be a good source. Whole chickens or rabbits can be used to provide nearly complete skeletons. These specimens unfortunately usually lack heads and feet, but the activities in this module do not require those parts. In all other meats (except fish) the available cuts include only disjointed or cut bones. However, the butcher may be willing to save some articulated joints or vertabrae from which the marketable meat has been trimmed.

The quickest way to prepare fresh bones for study is to boil off the meat. Immature and very small animals have many soft bones. These, as well as joint connections, may disintegrate with boiling. Thus, a mature stewing or roasting chicken may be the best choice. If time allows, students may be involved in the preparation of bones for study. A chicken lunch may be an added attraction with the cooking done at school.

To prepare the chicken, or other small animal, remove the skin and boil the whole carcass slowly until the meat begins to lift from the bones. Removal of the meat can be speeded by cutting off large portions of the meat prior to boiling. Use a paring knife and fingers to remove the meat. If possible, leave some of the joints, rib cage, and vertabrae connected. Collect the bones and wash them gently in soapy water to remove grease and allow them to thoroughly dry. Bones can be soaked in bleach to brighten their color. Caution students about exercising care with bleach.

Students should not be encouraged to bring in carcasses found in the environment unless all flesh has decayed from the bones, as the decaying carcasses may be sources of disease. Furthermore, it is illegal to pick up or possess the remains (including feathers) of any wild bird except house sparrows, starlings, and game birds legally collected with hunting licenses.

Procedure:

This activity takes quite a bit of time and should therefore precede or follow the resource person's visit. One or two students may want to do this activity as a special project. When studying bones, the work of Dr. Julie Glowacki in making new bones can be related (see "Women and Bones"). Have students do the following.

Prepare the chicken or other animal bones. Identify the bones, using the illustration on page 6 as a key, and lay out the bones with the head up and each wing and leg off to one side or the other. These bones can be glued and/or wired to poster board, and each bone can be labeled. (Smaller bones can be glued, but larger bones should be wired in place.)

For a more ambitious project, students can use wire, pins, and glue to assemble the entire skeleton. However, caution students that this is a fairly time consuming project.

Extension Activity 1: Comparative Anatomy

Materials:

- The bones arranged and labeled on a poster board from Activity II, or
- A set of bones including a vertebra, rib, sternum, clavicle, scapula, pelvis, wing, and leg.
- Copy of the diagram of a chicken skeleton, page 6.
- COMETS Challenge Cards (optional).

Procedure:

As in Activity I, students ideally will have their own sets of bones. (See Activity I for suggestions of sources of bones.) Assuming all students or small groups of students have their own sets of bones, the resource person can give these directions.

Use the diagram of the chicken skeleton to name each of the bones in your set. The following questions can be presented with Challenge Cards.

Find the chicken bone that matches your sternum (or breastbone). Have each student feel their own sternum. Why would the keel of the chicken's sternum be so pronounced, whereas you can find nothing comparable on the human sternum? (The bird's sternum has a large keel to allow attachment of the rather massive muscles for beating the wings for flight.)

Which chicken bone matches the human shoulder blade? Which chicken bones match the wrist and fingers? Which human bones match the chicken's wishbone? The following questions are not contained on Challenge Cards, but students could also identify these comparable bones in chickens and humans - vertebra, rib, pelvis, leg, and any other bones that may have been provided.

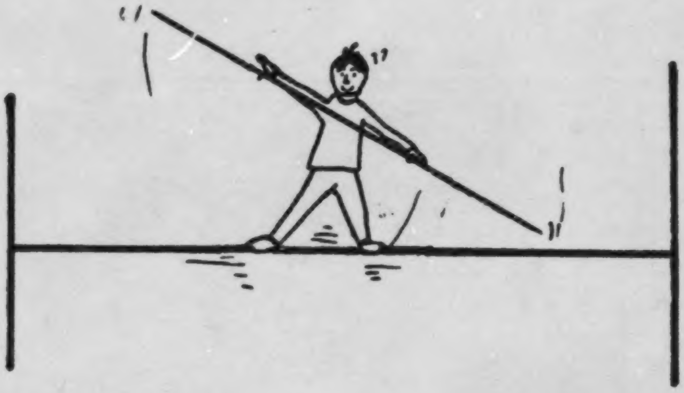
Activity III: The Human Machine

Materials:

- No special materials needed.

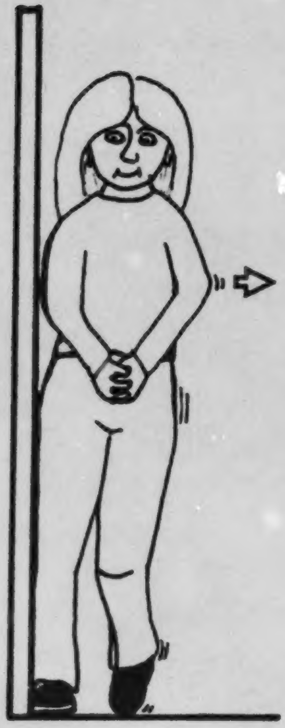
Background Information:

This activity demonstrates how the human body, like any other object, must follow basic mechanical concepts such as center of gravity. In order to maintain balance, a person must keep their center of gravity above their support. If the center of gravity is moved off-center, then a torque (twisting force) is felt and must be countered or else the person will fall. A toddler or tightrope walker or football player (or most any person) does not have to think about center of gravity and torque, but a toddler's contortions, a tightrope walker's swinging of arms, and a football player's crouching are employed in order to maintain balance. If the tightrope walker shown here leans to one side, the center of gravity is no longer over the support, a torque (twist) is felt, and the torque must be countered or else the tightrope walker will fall. The tightrope walker recovers balance (i.e., counters the torque) by twisting the rod to the side opposite their fall which moves the center of gravity back over the support and stops the fall.



Procedure:

The resource person should have a volunteer stand with hip and foot tight against the wall. Next, ask the volunteer to lift the outside foot without falling. It cannot be done. With hip and foot against the wall, the body's center of gravity is no longer over the support (the foot) and a torque is felt. The body falls away from the wall.



Especially younger students will all want to try this activity; and this desire should be satisfied before going on to talk about career or before doing the next activity.

Place a chair next to the wall and ask another volunteer to bend over with their head against the wall. They should be bent over far enough so that some of their weight is held against the wall. Have them pick up the chair with both hands and then stand upright without moving their feet. Again, their center of gravity is off-center and they have no leverage to counteract the torque which is forcing them to fall toward the wall.

Extension Activity 1: Cartwheel Momentum

Materials:

- No special equipment needed.

Procedure:

This activity should follow the preceding activity, if the resource person has time to do more than a brief activity and wishes to show additional human applications of physical concepts.

Have a student do a cartwheel. Ask them to slow the cartwheel to the point where they can just complete the cartwheel and then slow enough so that the cartwheel cannot be completed. Ask students to explain what they observed in terms of torque and center of gravity. (When the cartwheel is begun, the center of gravity is not over the support, so a torque "attempts" to twist the body back in the direction from which the cartwheel is started. However, the student's forward momentum counters this torque. If the momentum is sufficient, the student's body is carried forward; and the body's center of gravity moves above and then beyond the support, carrying the body to the completion of the cartwheel. However, if the momentum is insufficient, the torque causes the body to fall back. In summary, the body's motion is a summation of all forces acting on it. In this case, students are looking only at momentum and torque without being too concerned about the direction of these forces, the fact that momentum is the product of force and mass, and other forces acting on the body.)

Extension Activity 2: Keeping Balance

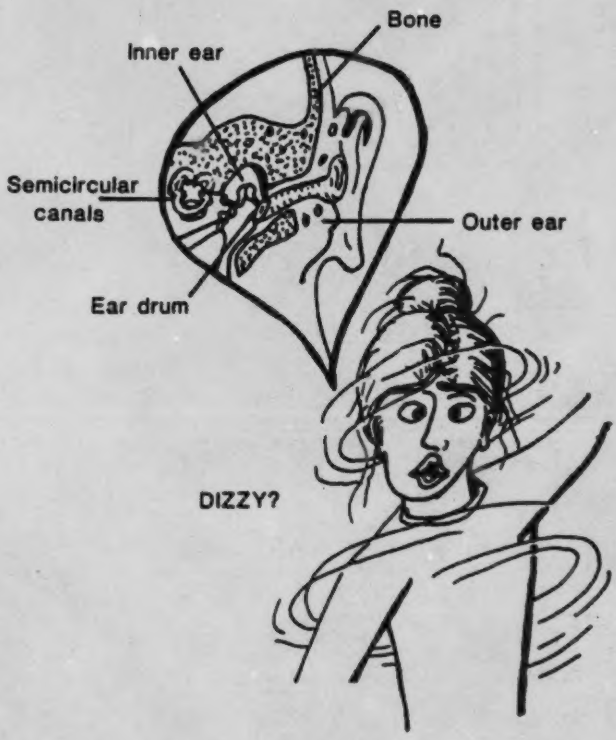
Materials:

- No special equipment needed.

Procedure:

This activity builds on the preceding activities.

Have a student volunteer to spin around until they can no longer keep their balance. Make certain this activity is done away from desk corners and other such potentially harmful objects, and spot the student to keep them from falling. Caution students not to repeat this activity without supervision. Have students explain their observations in terms of center of gravity and torque. (Torque is produced when the center of gravity becomes unbalanced. In order for the body to counter the effect of torque, the body must be able to sense which direction is up and down. If the body cannot do this sensing, then it cannot counter the torque, and the body topples over.)



Explain to students that the semicircular canals in the ears function to instruct the body which way is up or down. When the student spins around, liquid in the semicircular canals "splashes" around confusing the nerve endings in the canals. Conflicting messages about up and down are received by the brain which no longer knows "what's up." Therefore, the student can no longer counter the torque caused by an unbalanced center of gravity.

Career Information

This module is one of several which emphasize health careers. For information about physicians, see Fit N' Trim, about dentists, see Pearly Gates, about medical technologists, see Body Detectives, about nurses and health technicians (e.g., EKG), see Healing Techniques, about psychologists, see People Watchers, about optomatrists and related careers, see Light and Sight, and about pharmacists, see Pharmacy. Included here is information about veterinarians, physical therapists, and several types of medical practice.

The training and work of veterinarians and physicians are similar. Both need a strong background in mathematics and science, four years of undergraduate work, and after an intensive selection process, four years of professional training. However, the 33,500 veterinarians are less than one-fourth the number of physicians. Veterinarians are spread approximately evenly across three types of practice, small animals (pets, etc.), large animals (cows, etc.) and mixed small and large. Some work in federal meat inspection programs, with research animals, or with more unusual animals in zoos.

Physical therapists also need to study anatomy and other science courses, but their training is largely at the undergraduate level, although post-bachelor's study is available. Competition for entry into physical therapy training is intense. The P.T. specialist carries out a prescribed program of exercises and other treatments for problems primarily of the muscles, skeleton, and nervous system. Most work is done at a hospital, clinic, nursing home, or similar setting.

Several specialties related to the work of the physician have developed. Included among these practitioners are 8,100 podiatrists (who work with foot problems), 17,000 osteopathic physicians (who work primarily with muscular and skeletal problems and treat with manipulation and other means including drugs and surgery), and 18,000 chiropractors (who work primarily with problems of the nervous system and treat with manipulation and related techniques, but not by surgery or drugs). All of these specialties almost always require four years of undergraduate school with courses in science and mathematics and four years of graduate, professional work plus clinical experience. Practitioners of these specialties tend to be concentrated in areas near where they are trained and where there are hospital facilities for their practice.

Related Activities:

Klein, Aaron. *You and Your Body: A Book of Experiments to Perform on Yourself*. New York: Doubleday, 1977.

Career Information:

Lee, Mary Price. *Ms. Veterinarian*. Philadelphia: Westminister Press, 1976.

McHugh, Mary. *Veterinary Medicine and Animal Care Careers*. New York: Franklin Watts, 1977.

COMETS Profiles:

Jan Armstrong: Veterinarian.
Not the typical animal care giver, Jan Armstrong works primarily with zoo animals.

Cynthia "Sam" Booth: Athletic Trainer.
To provide assistance to injured athletes and to advise all of them on how to maintain and improve their conditioning, "Sam" Booth needs to be quite knowledgeable about the musculoskeletal system.

Carol Moddrell: Physician.
As a county coroner, Carol Moddrell needs to apply her understanding of anatomy to detect the probable cause of death.

Marian Washington: Basketball Coach.
Just as an athletic trainer needs to understand anatomy, a basketball coach like Marian Washington needs to study and apply anatomy and physiology.

For More Career Information Write:

American Chiropractic Association, 2200 Grand Ave., Des Moines, Iowa 50312.

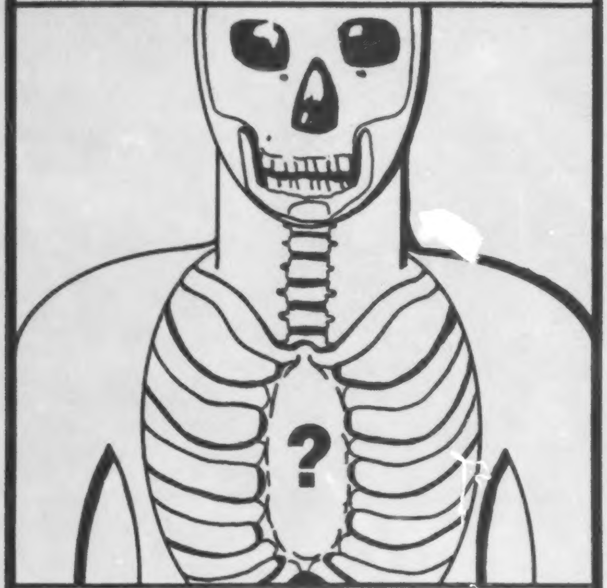
American Osteopathic Association, Department of Public Relations, 212 East Ohio Street, Chicago, Illinois 60611.

American Physical Therapy Association, 1156 15th Street, N.W., Washington, D.C. 20005.

American Podiatry Association, 20 Chevy Chase Circle, N.W., Washington, D.C. 20015.

American Veterinary Medicine Association, 930 North Meacham Road, Schaumburg, Illinois 60196. (Send self-addressed, stamped envelope for pamphlet, *Today's Veterinarian*.)

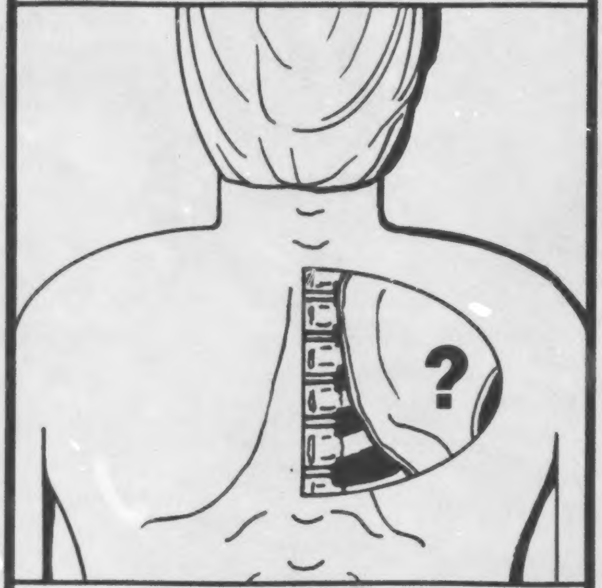
COMETS Challenge Card



Bones and Balance

Find the chicken bone that matches your sternum (breast bone).

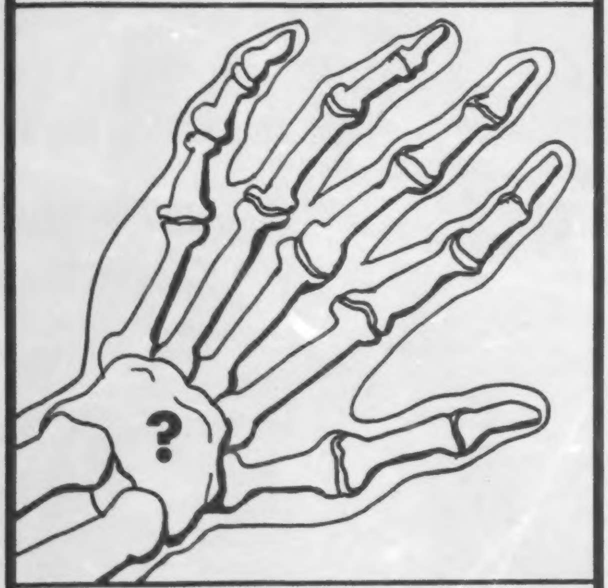
COMETS Challenge Card



Bones and Balance

Find the chicken bone that matches your shoulder blade (scapula).

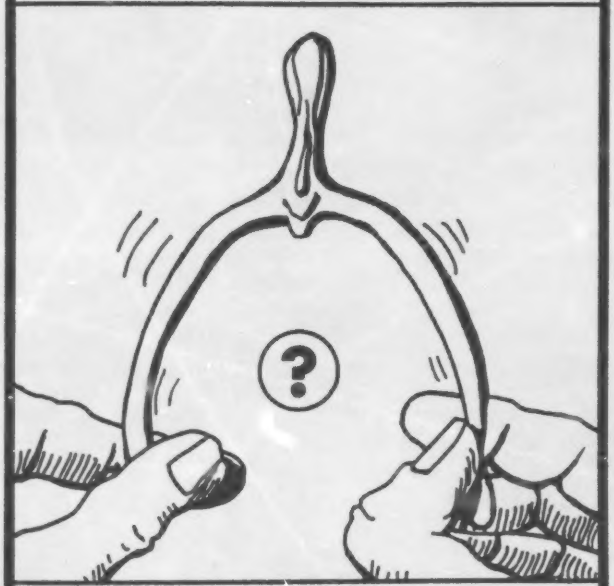
COMETS Challenge Card



Bones and Balance

Find the chicken bones that match your wrist and fingers.

COMETS Challenge Card



Bones and Balance

Find your bones that match the chicken's wishbone.

Career Oriented Modules to Explore Topics in Science

COMETS

TOPICS

Health
Genetics
Botany

Fit N' Trim

RESOURCE PEOPLE

Physician
Biologist
Health Career

THIS MODULE

Activity I

"Keeping Healthy" emphasizes the physician's or other health career person's role in preventive medicine. Students test their heart's recovery rate to gauge physical fitness. Main activity takes 15-20 minutes; possible extension activities are included. Activity could be done prior to or during resource person's visit. Minimal special equipment. Alternative resource people include physical educators, physical therapists, and others interested in maintaining personal health. Dr. Virginia Apgar's test of an infant's fitness relates to this activity (see "Women and Medicine"). This activity would fit well in units on physical fitness, heart and circulation, respiration, or various science processes ranging from observation to experimentation.

Activity II

"Roots" explores human genetic traits and emphasizes the hereditary and developmental nature of disease and fitness. Thus, it can be used in units on heredity, human development, or disease; it could be connected to a study of human reproduction and sex education or divorced from this area. Resource person can start visit with five minutes of students' observing a few of their own inherited traits; optional additional activities can be completed prior to or following the visit. No special equipment. Activity can be related to Drs. Taussig's and Kelsey's recognition of thalidomide's effect on normal foetal development.

Activity III

"Tissue Transplants" can be used in two diverse ways, related to either a physician's application of tissue transplant concepts or a biologist's understanding of plant growth. The activity takes several days, although much of it could be done outside class; and it probably should be completed prior to the resource person's visit. Special equipment needed. The activity can be related to Dr. Helen Taussig's codevelopment of a pulmonary artery bypass to save blue babies. It could be used in a unit on how the human body accepts or rejects foreign invaders, including tissue transplants and/or disease organisms, or in a unit on plant reproduction or parts of a plant.

University of Kansas School of Education Department of Curriculum and Instruction

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RELATED MODULES

Fit N' Trim is intended for physicians and other health people who could also be used with any of the following modules.

Bones and Balance

Student assembles a skeleton and studies its form and function.

Healing Techniques

Electrocardiograms or similar printouts are studied to determine heart activity.

Pharmacy

Effectiveness of antacids and antiseptics is investigated as a part of a more general study of drugs.

Body Detectives

Students determine an unknown liquid's acidity in an analogous fashion to the medical technologist's detective work.

WHERE TO FIND RESOURCE PERSON

Start with a family physician, who may come to your class, suggest other physicians, or refer you to a local medical society, public health agency, visiting nurses group, or hospital. Since premed is such a popular collegiate major, former students may help with this unit.

See the section, Career Information, at the end of this module and the related modules for other suggestions of health career people who might help with this module.

Additionally, any biology professor or related professionals could be used. Employees in state or federal agencies (e.g., Forestry Service, Fish and Game, or Agriculture Extension) could relate the genetics activity, "Roots", to their own work. Also, horticulturists and nursery workers could help teach the tissue transplant activity.

WOMEN AND MEDICINE

Today, as they have for many, many years, all doctors take the Hippocratic Oath upon entry to medical practice. The oath begins, "I swear by Apollo, the physician, and Asclepius and Hygieia and Panaceia and all the gods and goddesses..." While Apollo gained fame through the American space program, the two women physicians have become part of our everyday medical vocabulary - Hygieia as hygiene (health) and Panaceia as panacea (cure-all) .

As the Hippocratic Oath suggests, healers have always included women; but when medicine became a profession in the nineteenth century, women were denied access to medical schools, internships, and other aspects of training and practice. Some women were persistent though.

Several dressed like men in order to gain access to medical information. Some, like Elizabeth Blackwell, diligently applied and applied and applied to medical schools until they were accepted. Some, even after having gained admission to medical training, were forced to sit in the lecture hall or laboratory anteroom, as it was thought unseemly for them to receive training along with their male peers. In some cases women had to form separate medical schools for women only. As was the case in the education of Blacks, these separate facilities were not considered equal, and their graduates had to fight for their professional lives. However, some of these schools attained high standards and remain today. The bibliography lists several sources of information about women's struggle to take part in medical training.

Many contemporary women physicians have made outstanding discoveries in medicine. A few of those whose discoveries relate specifically to activities in this module include Dr. Virginia Apgar (1909 -), Dr. Helen Brooke Taussig (1898 -), and Dr. Frances Kelsey (1914 -).

Dr. Virginia Apgar, an anesthesiologist, developed the Newborn Scoring System, a measure for evaluating the vital functions of a newborn one minute and five minutes after birth. The Apgar Test gives a quick evaluation of physical condition and calls attention to needed emergency procedures. The Apgar Score rates an infant on a three point scale on each vital sign:

A - appearance or coloring
P - pulse
G - grimmace or reflex irritability
A - activity
R - respiration

Dr. Apgar was the first woman to become a full professor at Columbia Medical School, has assisted in the delivery of over 17,000 babies, and has written many articles on birth defects. You or a physician resource person using Activity I, "Keeping Healthy," may want to point out that the Apgar Test measures an infant's fitness, whereas the Harvard Step Test measures the students' fitness.

Dr. Helen Brooke Taussig was in charge of the cardiac unit at Johns Hopkins Hospital for eleven years. She often saw and grieved over the blue babies, newborn infants whose blue-tinged skin was caused by a shortage of oxygen in the blood. Often these babies died quite young. Dr. Taussig thought that the cause of this disease, pulmonary stenosis, might be due to a constriction of the pulmonary artery, which carries blood from the heart to the lungs for oxygenation. She persuaded a heart surgeon to make an artificial bypass from the heart to the lungs to get the blood around the blockage in the pulmonary artery. The surgeon experimented with animals and soon performed the first successful human bypass surgery, using what is now called the Blalock-Taussig method, and blue baby deaths became rare.

Dr. Taussig, the first woman president of the American Heart Association, was the first woman to receive the Passano Foundation Award for Medical Research. Activity III, "Tissue Transplants," could be related by you or the resource person to the Blalock-Taussig method.

While her work with blue babies is well known, Dr. Taussig also played a major role in recognizing that thalidomide, a sleep-inducing drug, results in horrid birth defects when taken by expectant mothers in early pregnancy. Dr. Frances Kelsey who worked with the Food and Drug Administration also realized thalidomide's detrimental side effects on the foetus. Dr. Kelsey saw to it that the drug was not approved for use in the U.S. Since thalidomide interferes with the normal foetal development controlled by the genetic code, you or your resource person should point out this connection to Activity II, "Roots."

Activity I: Keeping Healthy

Materials: 1234 +/-

- One watch or clock with second hand (or metronome).
- Bench, step, or pile of lumber of appropriate height for each student doing activity.

Procedure:

This activity emphasizes health and the physician's or other health resource person's recognition of a person's state of health. Dr. Virginia Apgar's test of infant fitness is described in Women and Medicine and should be mentioned to your students. However, this activity deals with your students' physical well being.

Some caution is required, but almost all your students should be able to perform the Harvard Step Test of physical fitness (see Olney, Ross. The Young Runner. New York: Lathrop, Lee & Sheppard. 1978), which is the basis of this activity. Your students should not perform this test if they have been told by a doctor that they have, or have had, a heart problem, high blood pressure, or bone or joint problems that might be aggravated by exercise, if they have frequent heart or chest pains, faintness, or dizziness, or if for any other reason they feel they shouldn't do the activity. Perhaps you could ask for a few volunteers to do the test, so that everyone unable to do the test would simply be a part of a large group of nonvolunteers and thus avoid embarrassment.

The test should take 15-20 minutes once the materials are ready. Find a sturdy bench 12 inches high (if the person doing the test is under 5 feet tall), 14" high if the person is 5' to 5'3", 16" if 5'3" to 5'9", 18" if 5'9" to 6', and 20" if over 6'. Before starting, tell the students they should stop if they become too tired. If a number of students perform the test simultaneously, assign each one a partner to record the data. Prior to doing the exercise have students practice finding their pulse and emphasize precision in doing the activity. See Finding Your Pulse, Extension Activity 1, page 7. If the resource person is going to have students perform the Harvard Step Test, then prior to the visit you probably should teach students how to take their pulse, in order to save time for the resource person.

At your command students step (not jump) from the floor up to the bench and back to the floor repeatedly, 30 times/minute for four minutes. Accurate counting is important; use a metronome or watch the clock to call out the cadence loud enough for each to hear. IF STUDENTS GET TOO TIRED, THEY SHOULD STOP. Of course, their score will be lower if they stop short of four minutes, but that's what the test is all about.

When the four minutes are up, have the students sit quietly and take their pulse beginning one minute, two minutes, and three minutes after the the end of the exercise. Each time they should count their pulse for 30 seconds. Calculate the RRI, Recovery Rate Index, using the following formula.

$$\text{RRI} = \frac{\text{Duration of exercise in seconds} \times 100}{\text{Sum of the three 30 second pulse counts} \times 2}$$

For example, if the person exercised for the entire four minutes (i.e., 60 seconds/minute x 4 minutes = 240 seconds) and had a 30 second pulse rate of 62 after one minute, 48 after two minutes, and 45 after three minutes (62 + 48 + 45 = 155), their RRI would be:

$$\text{RRI} = \frac{240 \times 100}{155 \times 2} = \frac{24000}{310} = 77.4$$

A rough interpretation of the RRI in terms of physical fitness can be derived from the following chart. Note that some physiologists have found the Harvard Step Test not useful for their research; but this chart can show students how higher scores are associated with better physical fitness.

< 60 - poor
61 - 70 - fair
71 - 80 - good
81 - 90 - very good
> 90 - excellent

Discuss the results, bringing out the facts that the blood carries oxygen which is involved in fulfilling the body's energy needs. When a person exercises, more oxygen is needed, so the heart beats faster to get blood distributed more quickly. By strengthening the cardiovascular system through a regimen of exercise, more blood can be circulated per heart beat and therefore fewer heartbeats are needed to supply the oxygen needs.

Under the direction of a physical education teacher or someone else knowledgeable about physical fitness programs for your age students, your students could enter into a physical fitness program and later (say, after three months) repeat the test.

Your physician resource person could comment on what bodily functions go into "physical fitness" as measured by the RRI and stress the importance of fitness for good all-around health. Our increased life span is not due as much to wonder drugs, surgical procedures, and new apparatus as it is to improved diet and the nearly total control of disease causing organisms.

Extension Activity 1: Finding Your Pulse

Materials:

- Wooden match or toothpick for each student (optional).
- Small piece of clay for each student (optional).
- One clock with second hand for all to see.

Procedure:

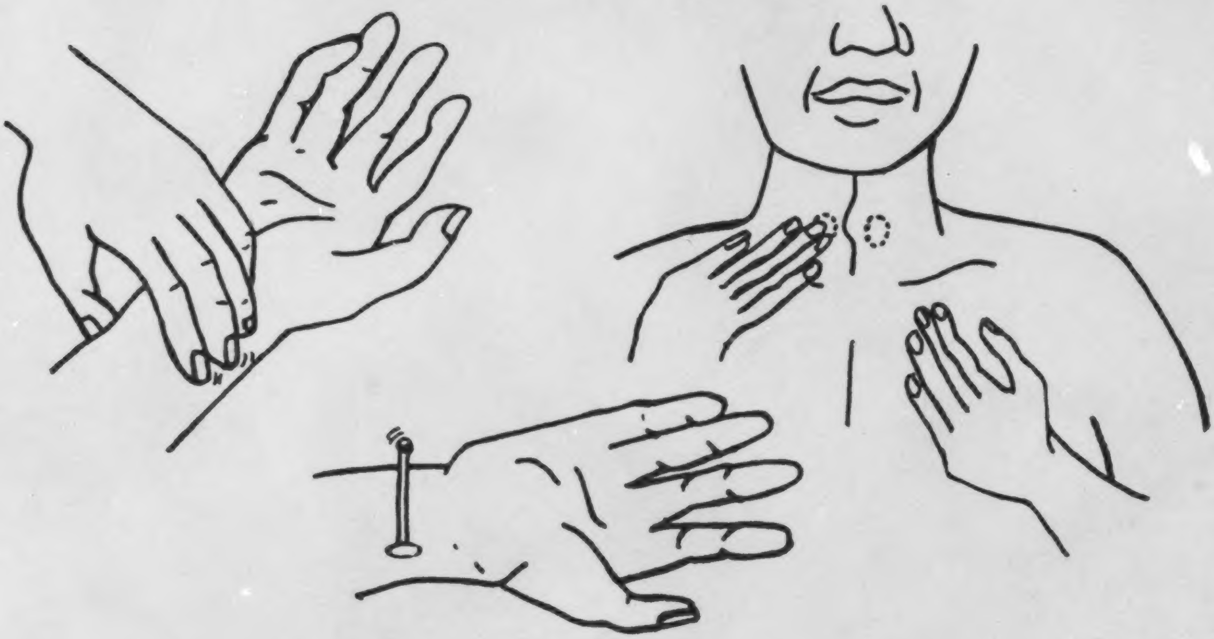
The heart is the strongest muscle in the human body. It can be thought of as two pumps working side by side. The right side pumps blood to your lungs where oxygen is picked up. The left side pumps oxygen-rich blood to the body.

A heartbeat can be heard, but the pulse must be felt. When the heart contracts, blood surges through the arteries which are elastic and swell in response to this surge of blood. When the heart relaxes, the surge of blood is reduced and the arteries return to their former diameter. Thus, the heart's rhythmic pattern of contractions and relaxations is perceived indirectly by feeling the expansion and contraction of arteries.

N

There are several spots on the human body where the arteries are close to the surface. These spots are called pulse points. (See HEALTH HELPERS, Activity III, "Emergency," for a drawing of these points.) The two that may be the easiest to find are on the wrist and the side of the neck.

Gentle finger pressure on the wrist is commonly used to measure the pulse rate. However, a toothpick or match fastened with clay over the artery in the wrist will move in a "throbbing" motion with each pulse. Either method may be used by the students. The pulse also can be felt in the neck to the right or left of the "Adam's Apple." Pressure should be applied gently, but in increasing amounts, until the pulse can be felt. If students have difficulty, ask them to do a little exercise (e.g., stand up and sit down 5-20 times) and then feel for their pulse which should become more pronounced through exercise. Because the thumb contains a pulse itself and thus makes it hard to use to get a good reading, be sure the students use their finger tips, not thumbs, to measure pulses.



Have students measure their own pulse (for perhaps 15 seconds or 30 seconds) and that of someone else while sitting at their desks. Record the values on the chalkboard. Be sure to have students determine the number of pulses per minute. Multiply by four or two, if they measured for only 15 or 30 seconds, respectively.

Extension Activity 2: Different Pulses

This activity is especially good as a follow-up to the resource person's visit. As an assignment for outside of class, have the students collect data to answer one or more of the following questions, which also appear on Challenge Cards, which could be duplicated and distributed to students.

- Do younger people have faster heartbeats than older people? (Include babies and senior citizens in the sample, if at all posible. Check answers with Table 1.)
- Is pulse rate related to body size? (Comparisons should be made involving animals also. Students can measure heartbeats of pets as well as do library research on heartbeat rates for various animals. Check answers with Table 2.)
- Do people who smoke have a different pulse rate than people of approximately the same age and size who do not smoke?
- Do pulse rates change during the day (under similar activity)? For example, a comparison could be made in the morning, after meals, and before going to bed.

Age	Approximate Pulse (Beats per Minute)
Baby	135
5 yr.	110
13 yr.	90
20 yr.	75
50 yr.	70
70 yr.	75

Table 1
Heartbeat and Age

Animal	Approximate Pulse (Beats per Minute)
Elephant	25
Horse	50
Human	75
Dog	100
Rabbit	175
Mouse	500
Shrew	1000

Table 2
Heartbeat and Size

Extension Activity 3: Breathing

Perform investigations similar to those in Extension Activity 2 using breathing rate rather than pulse rate as an indicator. Is there any correlation between breathing rate and pulse rate?

N

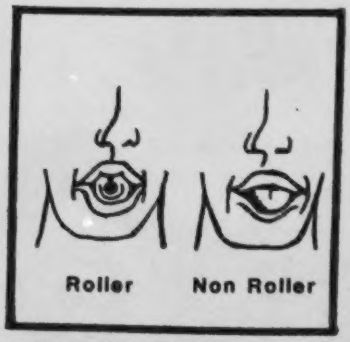
Activity II: Roots

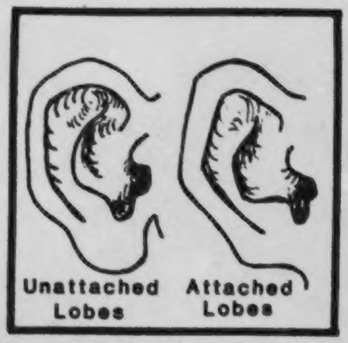
Procedure:

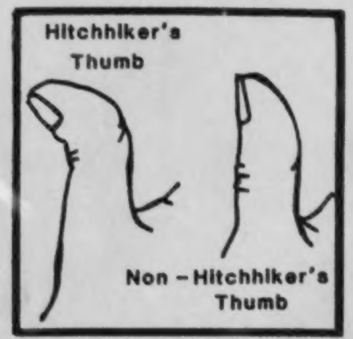
Many human characteristics are learned; others are inherited. Environmental and hereditary factors often interact. In this activity you will look at inherited human traits. Cystic fibrosis, Down's Syndrome, and galactosemia exemplify human conditions which are thought of as diseases or abnormalities, but which are due to inheritance rather than "germs," malnutrition, or other disease causers. At this time only the symptoms, and not the causes, of these inherited condition can be treated. In other words, once the condition is recognized, the victim's problems can be minimized through diet, exercise, and so forth, but the root cause, a genetic abnormality, cannot be eradicated.

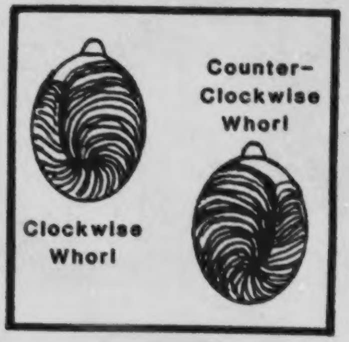
The resource person who desires a "brief" activity as an introduction to human genetics should ask how many students can roll their tongues. (Pairs of students should observe each other.)

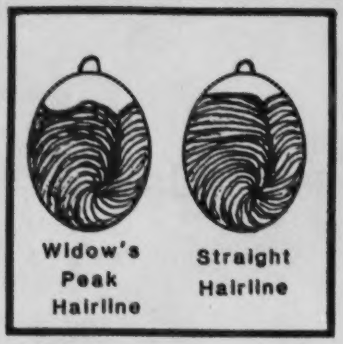
Some other human inherited traits are also fascinating. Students could observe earlobe attachment, thumb alignment, hair whorl, hairline, or hand-folding (people consistently place either their left or right thumb on top when folding their hands together.)

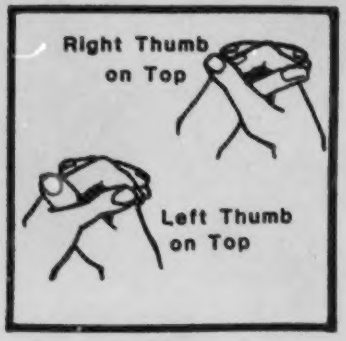

Roller
Non Roller


Unattached Lobes
Attached Lobes


Hitchhiker's Thumb
Non-Hitchhiker's Thumb


Counter-Clockwise Whorl
Clockwise Whorl


Widow's Peak Hairline
Straight Hairline


Right Thumb on Top
Left Thumb on Top

Extension Activity: My Family and Me

Materials:

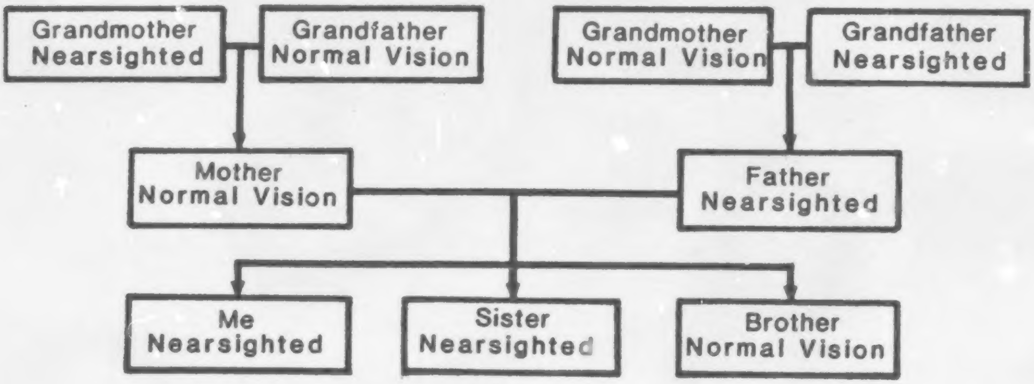
- Reproduce copies of Human Genetics Worksheet for each student.

Procedure:

You and your resource person can decide whether the following activity should be done prior to or following the visit.

Distribute the Human Genetics Worksheet to each student. Discuss the traits so students will know what they're observing. (Because of your knowledge of any special sensitivities of your students, you may want to make your own worksheet that omits some traits.) Suggest they gather data to the extent possible for parents, sisters and brothers, grandparents, and themselves. (Some students may not have access to many, if any, blood relatives. You may want to have students pair up and study one family; or students may be allowed to "adopt" a family on whom to collect data.) Remind them to indicate on the sheet which relative they were observing.

After they have collected the data, pick out a trait for which data for at least three generations are available and draw on the blackboard a sample family tree for that trait.


Grandmother Nearsighted
Grandfather Normal Vision
Grandmother Normal Vision
Grandfather Nearsighted
Mother Normal Vision
Father Nearsighted
Me Nearsighted
Sister Nearsighted
Brother Normal Vision

SAMPLE FAMILY TREE FOR VISION

After showing students this example, have them complete a family tree for two or three additional traits of their choice and then discuss these questions.

- Are there any traits which seem to "run in the family?"
- Are there any traits which some family members have, but others don't?

N

More Information

This is a good time to talk about *dominant* and *recessive* traits. For many of our human traits we inherit information about those traits from both parents. Thus, for each of these traits we have two inherited messages, called genes. If both genes (messages) are alike, then that's what we'll be. For example, if both parents at conception contributed a gene (message) that said "tongue roller," then we'd be a tongue roller. However, if the genes (messages) are not alike, then what we'll be is a result of the interaction of these two genes. In many cases (*but not all*) one gene will be *dominant* and the other gene will be *recessive*. (This has nothing to do with which parent contributed the gene.) When we inherit a dominant and recessive gene for, say, tongue rolling, then we will be whatever the dominant gene says we will be (and the presence of the recessive gene is hidden). In the case of tongue rolling, *not* being able to roll the tongue is dominant and being a tongue roller is recessive. Thus, for sure, a tongue roller has two recessive genes (each of which has the message, "you can roll your tongue"). However, a nontongue roller may possess *either* two genes that each say "you can't roll your tongue" *or* one gene may say "you can" while the other says "you can't."

This information can now be applied by your students to the information they collected on their worksheets to help understand why some traits seem to run in families and why some traits may appear in children but not in parents. Caution your students that many human characteristics are inherited in ways more complex than this relatively simple dominant/recessive model; so, for example, if someone had a dominant trait, but all their ancestors had the companion recessive trait, this doesn't mean something is wrong with them. It may only mean that that particular trait is inherited in one of the many other patterns that differ from the dominant/recessive model.

One example of the physician's use of genetics is in the disease, cystic fibrosis, which annually affects about 1200 newborns. Symptoms, which usually do not appear until childhood, include respiratory infection, failure to grow, and blockage of the small intestines. Because of the inherited nature of the disease, it cannot be cured. Only the symptoms can be treated during the victim's average lifespan of 19 years.

The gene for cystic fibrosis acts as a recessive gene in the same manner as the recessive gene for tongue rolling. If each of two parents have this recessive gene plus the dominant, non-cystic fibrosis gene, then they will not suffer the disease and the recessive gene's presence will be undetected (unless a recently developed test for the gene's presence is used). These two "carrier" parents have a 25% chance of bearing a child who would have cystic fibrosis due to the child's receiving the recessive gene from each parent. (Of course, these same "carrier" parents have a 75% chance of producing a normal child. Their child would be normal if the child received the dominant, non-cystic fibrosis gene from the mother or the father or from both parents.)

What are the chances of bearing a child with cystic fibrosis? First, only about 4-5% of adults carry the defective gene, so the chances of two of these "carriers" being parents of the same child are about one in six hundred. Since only 25% of these parents' children will suffer cystic fibrosis, we can conclude that the chances that any particular newborn will have cystic fibrosis is very small, approximately one in 2400. Of course, however, if there is a history of cystic fibrosis in the family of one or both parents, then their chances of bearing a child with cystic fibrosis are increased. By consulting with a physician or someone else knowledgeable about genetic counseling, a couple can receive information about their chances of bearing children with a particular genetic abnormality and use this information in making child bearing decisions.

This would be a good point to relate how doctors are concerned about normal and abnormal development, based on genetic information. Discuss how Taussig and Kelsey (see "Women and Medicine") uncovered the deleterious effect thalidomide has on foetal development. If drug use and misuse is a topic of your course, the relationship of drugs and development could be described.

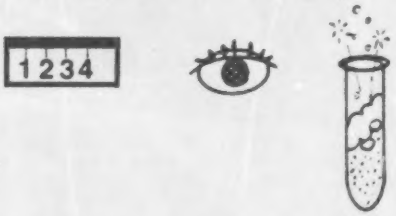
HUMAN GENETICS WORKSHEET

	Roll Tongue?	Ear Lobes Attached?	Hitchhiker's Thumb ?	Widow's Peak?	Fold Hands With Right Thumb on Top?	Only Use Right Hand for Writing etc.?	Dimples?	Freckles?	☐ Add Your Own Trait.
Me	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
________ Relative	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
________ Relative	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
________ Relative	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
________ Relative	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
________ Relative	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
________ Relative	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
________ Relative	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
________ Relative	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No
________ Relative	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No	Yes No

Fill in this worksheet for yourself for each genetic trait. If you have the trait such as tongue rolling, circle yes; otherwise circle no. Talk with or observe several of your blood relatives - parents, brothers, sisters, grandparents, aunts, uncles, cousins. Fill in one row for each relative observed. Do any of these traits "run in the family?" Is there another trait such as curliness of hair that often occurs in the family? Add that trait to the last column on the right and collect information from your relatives about it.

Activity III: Tissue Transplants

Materials



- Green twig.
- Well rooted plant.
- Tape.
- Grafting wax (available from nursery) or beeswax.

Procedure:

Organ transplants are here to stay! As described in Women and Medicine, the Blalock-Taussig method of implanting an artificial artery has saved many otherwise doomed infants. Transplants of hearts, corneas, kidneys, and other vital organs are so commonplace today that they no longer command the headlines they did only a little over a decade ago. By simply signing a form printed on the back of their driver's license, in many states people can indicate their desire to donate body parts to be used as transplants when they die.

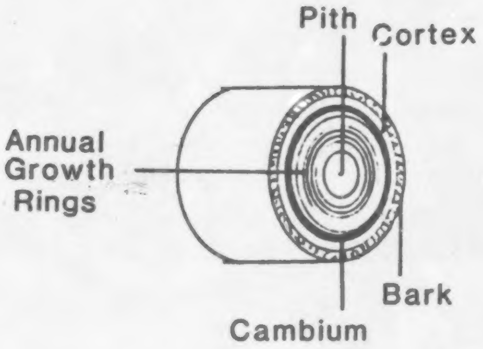
While organ transplants are a relatively new surgical procedure, autotransplants (where a part of one's body is donated to another part of the body) began nearly 3,000 years ago when Hindu surgeons repaired damaged noses by folding a flap of skin from the forehead or cheek over to the nose. When the graft had "taken," the former connection to the forehead or cheek was severed. Today skin grafts are common practice in burns, and many people also have blood vessels removed from one part of their body to repair damaged aortas or other vessels elsewhere in their body.

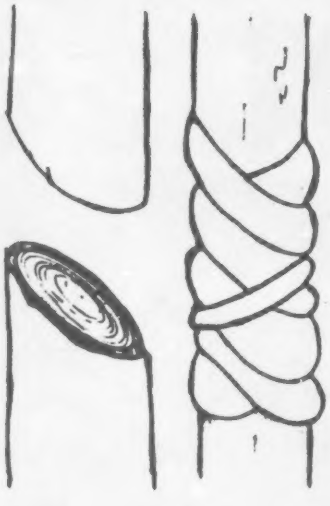
Transplants, nonetheless, are still "tricky" because our body's natural defenses react strongly to reject "invading" tissue. The same defense system that protects us against disease germs causes our body to reject foreign tissue transplants. Success in transplants thus depends upon knowledge of our body's natural defense system and development of techniques to circumvent those defenses. Tissue typing, which matches recipients and prospective donor tissue, has greatly increased chances for successful transplants.

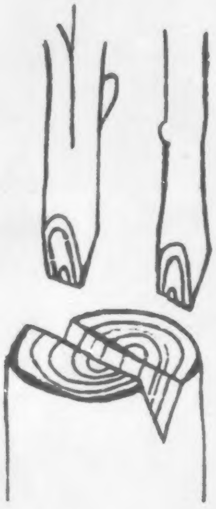
Since animal tissue transplants are so difficult, and moreover, such animal experimentation for demonstration purposes is discouraged, this activity is based on plant tissue transplants. Despite the vast differences between plants and animals, the general principles of transplant success in each type of organism are analogous. Because of the long time span required in this activity, if it is chosen by you and the resource person, you should start the activity well ahead of the resource person's visit and the visitor should only comment on the activity and its career relevance.

To graft plant material, choose two plants of the same species. Select branches no more than 1" thick (preferably 1/4 - 1/2" in diameter) and cut branches off the two plants. Attach the severed branch of each plant to the freshly cut branch stump of the other plant. Place the cambium layers (the green tissue just beneath the bark) of both plants together. Grafting is easier if the scion (the donated part) and stump of the recipient are of equal diameter and have been cut diagonally to give as large an overlap of tissues as possible. The scion must have several buds. With the two cambium layers in contact, bind the juncture with tape and seal with grafting wax.

Another grafting method involves sawing a one inch diameter branch and splitting the stub that remains. Insert two twigs of small size, the ends of which have been sharpened to the shape of a wedge. Place the two twigs near the outer edges of the branch split so that the two cambium layers are in contact. When the two growing surfaces are in contact, sap can flow from one plant to the other. Bind with tape and seal all cut surfaces with wax.







Students can try grafting techniques on plants in the school yard or on potted plants in the classroom. (Get permission first!) They should carefully note successes and failures as they attempt grafts where the donor is the same plant (graft a branch from one part of the tree to another branch), the same species, a related species (e.g., a pear to an apple), or an unrelated species. For example, the pear can be grafted successfully to an apple; but a tomato to potato graft would be unsuccessful.

Career Information

Earning a Medical Degree requires between six and eight years of college training, a year of internship, and one or more years of residency for a specialty field. Physicians earn a well above average salary and command high regard in their communities; but the practice of medicine requires a long, arduous training program and longer than average hours on the job. Physicians need not only a strong academic background emphsizing the sciences but also an empathy for people and their problems, a keen diagnostic sense much like that of a detective, and an ability to act decisively under the most trying conditions. (The Making of a Woman Surgeon by Dr. Elizabeth Morgan, New York: G.P. Putnam, 1980, provides a graphic picture of medical training. This book is recommended for the teacher. The COMETS Profile, Valya Visser: Neonatologist, features a woman whose medical career revolves around the treatment of prematurely born babies.)

In using this module, remember physician is only one of many health careers. Help students look at the entire range including these examples.

Dentist
Optician
Pharmacist
X-ray Technologist
Hospital Administrator
Medical Records Administrator
Laboratory Technician
Physical Therapist
Speech Pathologist

Too many young people prematurely narrow their career choice to physician. Health career opportunities are much broader; not everyone can be The Doctor.

Many students who are interested in science turn first to health careers because of their already developed familiarity with a few of these careers. Encourage these science prone students to broaden their focus. (Use other COMETS modules for this purpose.)

Related Activities:

Allison, Linda. Blood and Guts: A Working Guide to Your Own Insides. Boston: Little Brown. 1976.

HAP, Health Activities Project. Published by Hubbard, PO Box 104, Northbrook, Illinois 66062. Developed by Lawrence Hall of Science, University of California, Berkeley. 64 student-centered activities organized into 13 modules in health, science, and physical education designed for grades 4-8.

Career Information:

Jochnowitz, Carol. Careers in Medicine for the New Woman. New York: Franklin Watts, 1978. (Information about medical school, training, research, private practice, and public health.)

See also Bibliography of Biographies in Teachers Guide.

About Women in Medicine: (for the teacher)

Ehrenreich, Barbara and English, Deider. Witches, Midwives and Nurses. New York: Feminist Press. 1973.

Marks, Geoffrey and Beatty, William. Women in White. New York: Charles Scribner, 1972.

Schacher, Susan, ed. Hypathia's Sister's : Biographies of Women Scientists --- Past and Present. Feminists Northwest, 5038 Nicklas Place, N.E., Seattle, Washington 98105, 1976.

Walsh, Mary Roth. Doctors Wanted: No Women Need Apply. New Haven: Yale University Press, 1977. (History of women and the medical profession from 1835 to 1975.)

COMETS Profiles:

Cynthia "Sam" Booth: Athletic Trainer.

Sports medicine, a growing field especially for women, is represented by "Sam" Booth, the trainer for women's teams at a major midwestern university.

Valya Visser: Neonatologist.

As a medical educator and practitioner, Dr. Val Visser specializes in the treatment of prematurely born babies.

Other Profiles feature various health career people including a nurse, pharmacist, dietician, dentist, and several physicians.

For More Career Information Write:

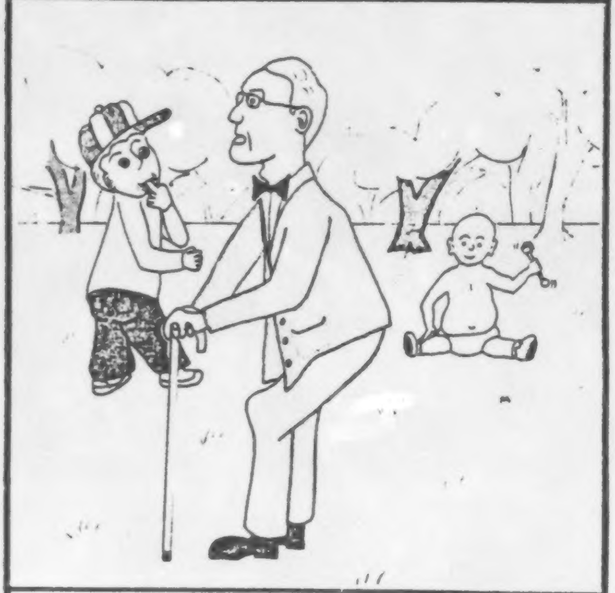
American Medical Association, 535 North Dearborn Street, Chicago, Illinois 60610.

American Medical Women's Association, 1740 Broadway, New York, New York 10019.

American Osteopathic Association, 212 East Ohio Street, Chicago, Illinois 60611.

Also, write other sources listed in related health modules.

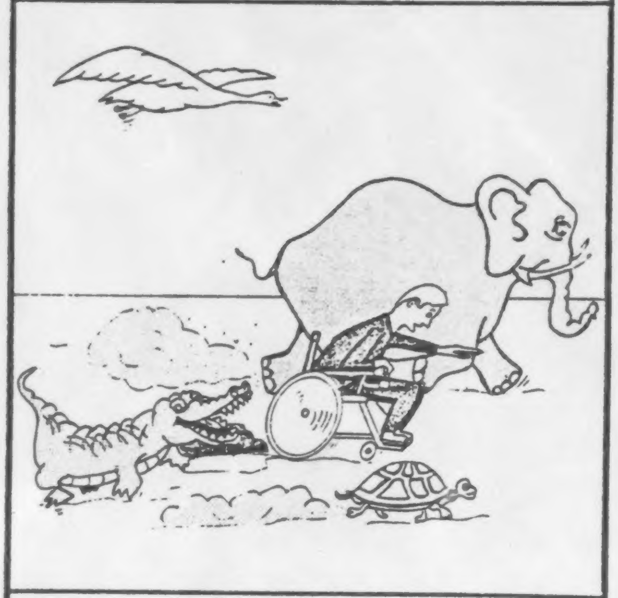
COMETS Challenge Card



Fit N' Trim

Do younger and older people have the same heartbeat?

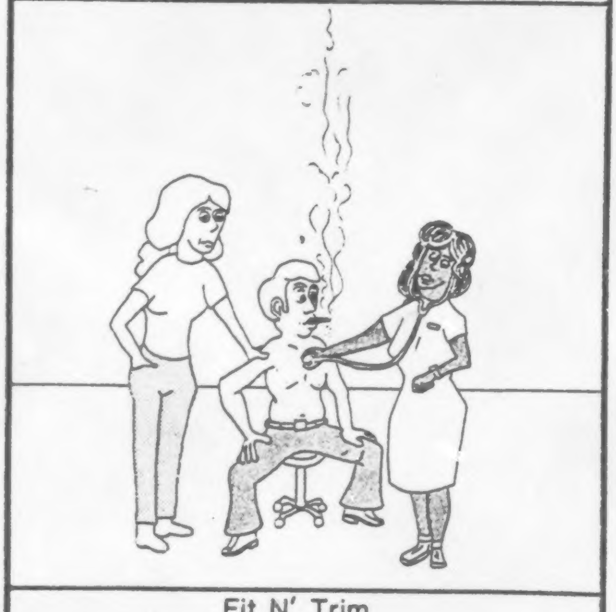
COMETS Challenge Card



FIT N' TRIM

Do smaller or larger animals have faster heartbeats?

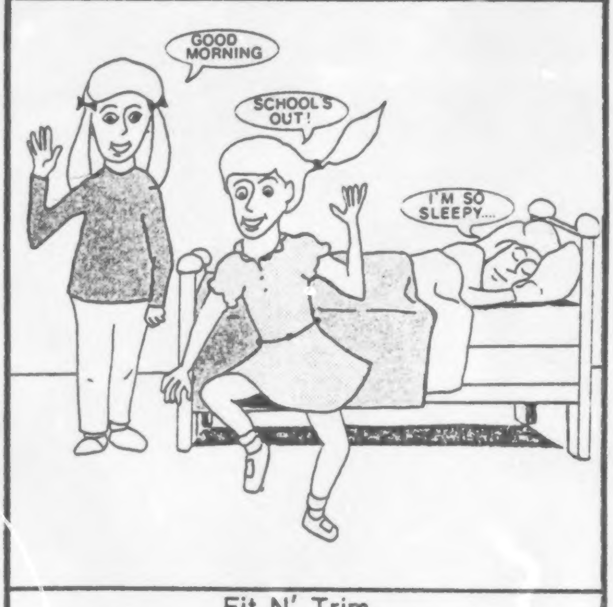
COMETS Challenge Card



Fit N' Trim

Does smoking affect how fast the heart beats?

COMETS Challenge Card


GOOD MORNING
SCHOOL'S OUT!
I'M SO SLEEPY....

Fit N' Trim

Does the heart rate change throughout the day?

Career Oriented Modules to COMETS Explore Topics in Science

TOPICS

Health
Anatomy
Circulation

Healing Techniques

RESOURCE PEOPLE

EKG, EEG, X-RAY, or Emergency Technicians
Nurse

THIS MODULE

Activity I

In "Squiggly Lines" students look at EKG's of normal and abnormal hearts and relate these printouts to their own pulses. One or more EKG's should be made into transparancies or student handouts. No other equipment is necessary. The activity can be brief. EKG technicians, nurses, or other health career people could be used as resource people. An EEG technician could substitute an EEG for the EKG. The work of Laurel van der Wal could be mentioned (see "Women and Health"). The activity would fit well in a unit on circulation and the heart.

Activity II

Students look at X-rays in "What's In There?," interpret shadows cast by a sphere, cylinder, and cone, and relate this to X-ray interpretations. This activity could be taught in a unit on anatomy, health, or the specific body part shown in the X-ray. Resource people could be selected from X-ray technicians, dental technicians, and other health career people, or metallurgical engineers or others who inspect welds with X-rays. X-rays should be provided by the resource person. The activity can be brief. The work of Edith Quimby to set radiation treatment dosages (see "Women and Health") and of Dorothy Crowfoot Hodgkin and Rosalind Franklin to determine crystalline structures (see "Women and Crystallography" in Misc. Materials) can be described here.

Activity III

"Circulation" uses Challenge Cards to demonstrate circulation in humans, goldfish, daphnia, and earthworms. In an extension activity, "Emergency," students learn resuscitation techniques. Some special equipment is required. The activity can be made brief, if desired. Emergency technicians, nurses, or other health career people should be used as resource people. The work of Estelle Ramey with endocrinology and circulation can be related here (see "Women and Health").

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RELATED MODULES

This module could be used with almost any health career person, but it is primarily intended for nurses and for various health technicians. These resource people may also be used with the following modules.

Body Detectives

Students use red cabbage juice to detect the pH of a solution much as medical technologists do body chemistry work.

Fit N' Trim

Genetics, physical fitness, and tissue transplants are investigated.

Bones and Balance

Students study chicken skeletons to learn about their own bones and apply physics concepts of center of gravity and torque to their own bodies.

Pharmacy

Activities are included to demonstrate development and action of drugs.

Pearly Gates

Characteristics of teeth and some spatial skills used by dentists serve as the focus of this module.

WHERE TO FIND RESOURCE PEOPLE

Since so many people pursue health careers, students' parents may be the best source of resource people for Healing Techniques. X-ray, EKG, EEG, and emergency technicians can be contacted through hospitals and public or private clinics. Emergency technicians are also employed by ambulance services, fire departments, civil defense, and so forth. Nurses can be contacted through hospitals and clinics, a visiting nurse program, nursing homes, or public health facilities. Look in the yellow pages for dentists and through them, dental technicians. Look in the yellow pages under physician for radiologists (doctors who specialize in applications of X-rays and similar techniques), cardiologists (heart specialists), and neurologists (brain and nervous system specialists). Biologists could serve as resource people for the "Circulation" activity (see Outdoor People for suggestions of where to find biologists). People who use X-rays to inspect welds can be found in manufacturing industries.

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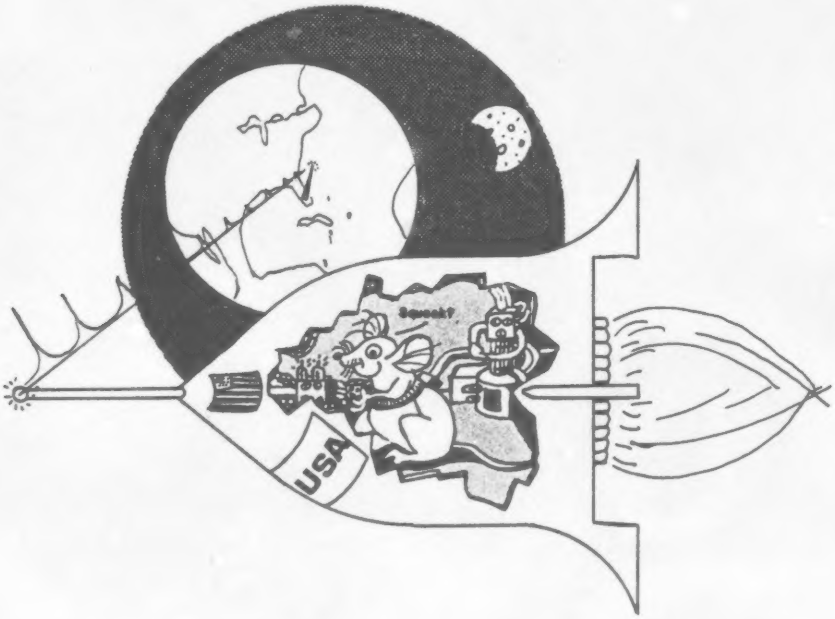
Women and Health

Whenever X-ray examinations of the teeth or other parts of the body are made or radiation treatments of any kind are given, some aspects of Dr. Edith Quimby's contributions to the science of radiology are used. In the early twentieth century, physicians became aware of the powerful diagnostic and therapeutic applications of a new tool, radiation, but the tool was in a quite crude form. What treatment should be given to a 170 pound person with a small tumor seven inches below the skin or to a 100 pound person with a large tumor two inches below the skull? Quite simply, the precise radiation treatment was not known. What Edith Quimby did was move the use of radiation from a guessing game to an exact science. Quimby measured how much radiation was emitted from various sources, how much of this radiation was delivered through the air, and how much penetrated through various tissues to different depths. Thus, by applying this information, relatively safe levels of radiation could be used in diagnosis and sufficient, but not too much, radiation could be delivered in therapy.

Laurel van der Wal had several interesting careers, including working on engineering problems of space flight for animals and people. In 1958 during the early days of space flight, she was responsible for Project Mia, in which two mice, Benji and Laska, were sent into space. Van der Wal developed the



equipment necessary for monitoring the mice's heartbeats and telemetering this information back to earth. These and other data gathered by Laurel van der Wal about the physiological effects of space flight guided the succeeding stages of space flight in which dogs and then astronauts were sent up in rockets. (A note about van der Wal's interesting careers which show that people in science careers do not forever and only pursue the work for which they are honored: According to her citation for a Society of Women Engineers award, prior to her work as a space engineer, Laurel van der Wal was a professional model, art instructor, deputy sheriff, gambling casino dealer, and railroad switch tower operator.)

Dr. Estelle Ramey has pursued a rich career in endocrinology, both as a researcher and teacher, and also as a noted speaker, public servant, and leading advocate for women in science careers. Endocrinology is the study of hormones, secretions of the body which are carried in the circulatory system and which regulate the body's physiological processes from the development of secondary sex characteristics in puberty to the maintenance of proper levels of sugar, potassium, and other substances in the blood. One of Dr. Estelle Ramey's early projects was to study the job performed by cortisone and other steroids during stress. A more recent avenue of study has been the question of why men die earlier than women of heart disease (see the mortality table worksheet in Figures Don't Lie for an indication of the differences in life expectancies of men and women). What she and her colleagues have found is that the male hormones increase the incidence of blood clot formation. This effect is not due simply to the presence of the hormone, for indeed females and males both produce both male and female hormones. The problem, rather, seems to result from the relative balance of the male and female hormones. One avenue of countering the tendency to form clots which was investigated in rats was to give additional dosages of female hormones to the males, but this treatment feminized the males without reducing the clotting tendency. Thus, it would appear that the problem is more complex than simply balancing the levels of male and female hormones in the circulatory system; but the solution is not known, and Estelle Ramey and her colleagues continue to study the problem.

Activity I: Squiggly Lines

Materials:

- EKG printout from next page (made into an overhead transparency and/or copied for each student's use).
- Stethoscope (optional).

Background Information:

More and more specialized diagnostic tools are joining X-ray machines and stethoscopes which have been available for decades. A CAT Scanner (Computerized Axial Tomography) can take a three dimensional picture of body parts, whereas an X-ray provides only a two-dimensional picture. In many cases the CAT scan can replace exploratory surgery. Another development, ultrasound, allows high pitched sound to be passed through the body in place of X-rays but with similar results. The varying densities of body tissues absorb sound to varying degrees (just as they absorb X-rays to varying degree), producing a sonagram, a "picture" of the resultant varying amounts of transmitted sounds that can be interpreted as an X-ray can be interpreted. One distinct advantage of ultrasound is its reduced risk to the patient, since X-rays are not used. A sonagram, for instance, could be made of a developing foetus to spot potential problems and perhaps allow timely treatment, whereas the risk associated with X-rays may be so great as to preclude their use.

A less exotic detection tool, the electrocardiograph (EKG), provides a printed, graphic "picture" of the heart's functioning and is the focus of this activity. The EEG, electroencephalograph, similarly provides a printed, graphic "picture" of the electrical activity of the brain; and if an EEG technician is the resource person, the EEG should be substituted for the EKG. (The EKG has the instructional advantage over the EEG of the students' being able to feel their pulse and relate this to the EKG).

Procedure:

Have students feel their pulse while showing them a normal EKG printout on the overhead projector (and/or on worksheets distributed to students). Point out to them the peaks and valleys on the EKG and associate those major features with what the students are feeling. If a stethoscope is available and the resource person has time for a longer activity, the students could look at the EKG while listening to their heart.

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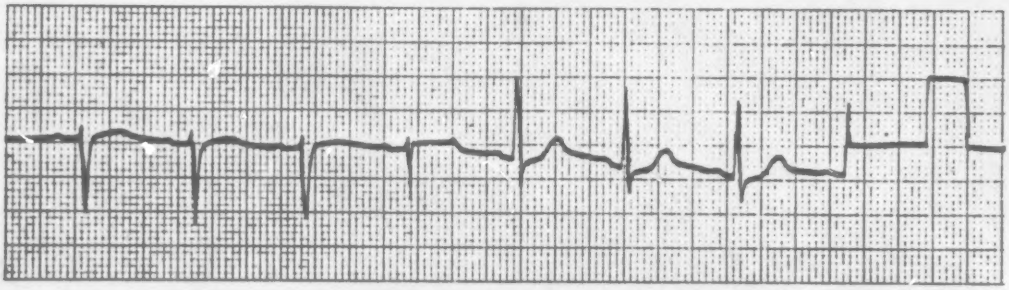
Sample Portion of a Normal EKG Printout



The resource person should also show and describe one or more abnormal EKG's. If the activity is being conducted at the hospital or doctor's office, an EKG might be run on a student volunteer; or a student volunteer might have an EKG run by the resource person prior to the classroom visit, and this EKG could be shown to the class. The work of Laurel van der Wal with remote detection of physiological processes in space flight should be mentioned here (see "Women and Health").

CHART NO. 3
1
2
3
4
HOW DO I FIND OUT IF MY GIZZARD IS OK?

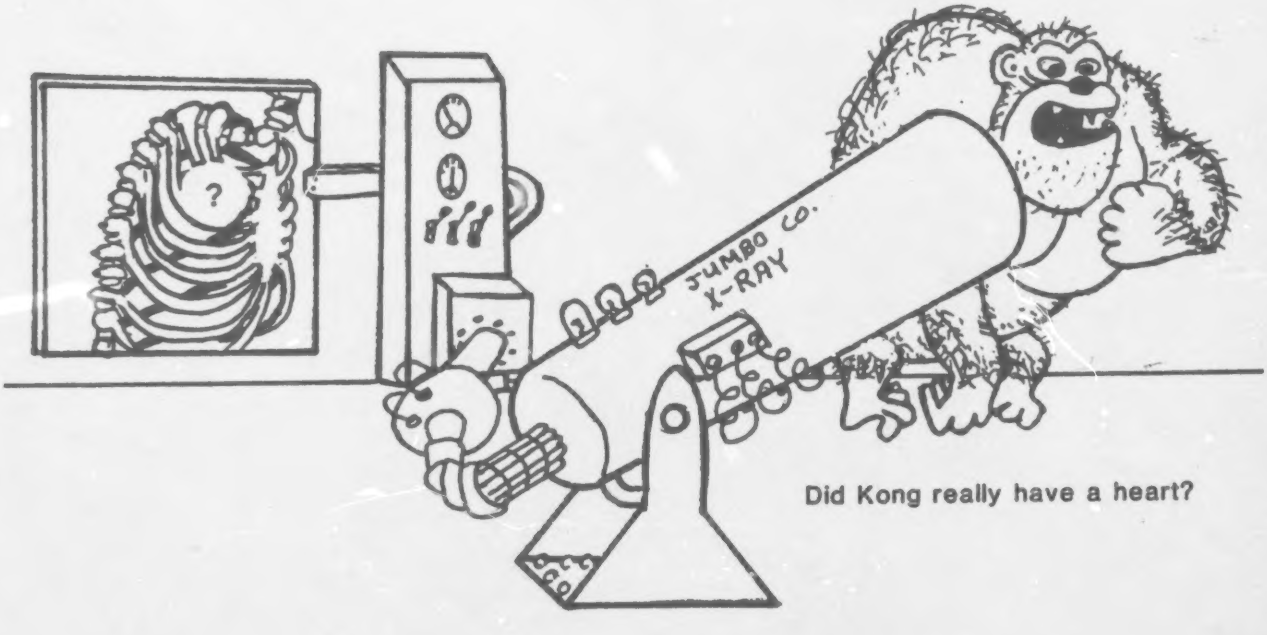
Activity II: What's in There?

Materials:

- X-rays (provided by resource person. Try to have X-rays of both normal and abnormal individuals, e.g., broken and healed bone, healthy teeth and teeth with cavities, or a normal organ and one with a tumor.)

Procedure:

The resource person should show a series of X-rays on the overhead projector and describe what is shown. The treatment that would be prescribed on the basis of X-ray evidence could also be described. They can then discuss the uses of X-rays for both diagnostic and therapeutic purposes, and they may describe new techniques such as CAT scans and sonagrams. Finally, the pioneering work of Edith Quimby in developing techniques for determining how much radiation should be used in treatment can be related here (see "Women and Health").



Did Kong really have a heart?

As the X-rays are being shown, the resource person may also choose to do the first extension activity to give students a better grasp of the skills involved in interpreting an X-ray.

Extension Activity 1: Shadows

Materials:

- Sphere (e.g. tennis ball or orange).
- Cylinder (e.g. small juice can).
- Cone (e.g. ice cream cone).
- Cardboard screen to hide objects on the overhead projector.

Procedure:

This activity could be done in conjunction with Activity II or as a separate activity prior to or following the resource person's visit.

Keeping the objects well hidden behind a screen, place a sphere, cylinder, or cone on the overhead projector and project its shadow. Rotate the object 90 degrees, so the students will see a new shadow, and repeat so that a third plane can be seen. Repeat with the other two objects. The students should describe each object's shape based on the shadows they see.

Ask students to compare the circular shadows produced by the sphere, cone, and cylinder. They should note that all three shadows are similar in being round, but they are different in that the sphere's shadow is lighter around the edges, while the other shadows are more uniformly dark. The students have begun to see how flat shadows can be used to provide some information about a third dimension, even though a two-dimensional picture has been provided.

The work of Dorothy Crowfoot Hodgkin and Rosalind Franklin may be related here (see "Women and Crystallography" in Misc. Materials). They interpreted the pattern of deflected X-rays to figure out the three-dimensional structure of vitamins, penicillin, and DNA.

Activity III: Circulation

Materials:

- Earthworm, daphnia, and/or goldfish.
- Cotton or paper towel.
- Glass dish (e.g., half of petri plate).
- Water.
- Hand lens.
- Microscope or microprojector.
- Challenge Cards (optional).

Procedure:

This activity is intended to show circulation in humans, another vertebrate (fish), and invertebrates (earthworm and/or daphnia). The resource person could use any or all the activities described on the Challenge Cards. If a brief activity is desired, only the human circulation activity could be used or the goldfish's circulation could be shown to the class with a microprojector. Here are some notes regarding each of the Challenge Cards.

When you press down only at point A on the human hand, there should be no change in the blood vessel. When the index finger is rubbed from B to C (observation 2), the blood vessel, a vein, should disappear because you are wiping out the blood and flattening the vessel. When the index finger is raised (observation 3), the blood vessel should remain collapsed and thus not visible, because a valve at C keeps blood from moving back into the collapsed vessel; and the blood supply is still blocked at A by the middle finger. Finally, when the middle finger is raised (observation 4), the blood returns to the vessel and it reappears. Based on this evidence, students should conclude that the blood is moving from A to C and that there is a valve at C.

To observe circulation in the capillaries of the goldfish, wrap it in wet cotton (to keep it alive), or a wet paper towel may be used (but is less preferable). Place the wrapped goldfish in a shallow layer of water in a shallow glass dish and spread out the goldfish's tail. Observe through a microscope under low and then high power. If a microprojector is available, the whole class can see the circulation together, thus speeding up the activity and ensuring that everyone will get to see the circulation. Make sure the goldfish stays moist and return it to the aquarium as soon as possible.

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The pulse of the daphnia (water flea) can be seen under a hand lens or low power of a microscope. The very rapidly beating heart is just behind the eye. The pulse of the earthworm can be seen unaided or with a hand lens in the dorsal blood vessel on top of the earthworm. Some experimentation is possible with these animals. Vary the temperature (e.g., place the animal in a refrigerator) and then observe the pulse.

The work of Estelle Ramey on endocrinology and circulation can be related here (see "Women and Health").

Extension Activity 1: Emergency

Materials:

- Rescue Annie, a doll used in CPR, WSI, and other first aid training courses (optional).
- Sample rescue equipment such as oxygen mask (optional).

Procedure:

"Is the patient breathing? Is the heart beating?" These are the first two questions asked by a health worker who arrives first at the scene of a medical emergency. As a follow-up to Activity III or as a separate activity, the resource person could demonstrate resuscitation techniques used to restore breathing and/or circulation. If a demonstration doll, Rescue Annie, is available, it could be used, or a volunteer student could be used to show CPR techniques. Emergency equipment, if available, could be shown and their function explained. Especially if the resource person works with accident victims, pressure points could be shown and techniques for stopping bleeding demonstrated.

Career Information

The need for health technicians has grown in order to operate new devices which have become more available, to provide trained medical assistance in emergencies, and to relieve the more highly trained health professionals of routine tasks. Thus, we now have 20,000 electrocardiograph (EKG) technicians, 7,000 electroencephalograph (EEG) technicians, 115,000 paid and 175,000 volunteer emergency medical technicians (EMT), 35,000 operating room technicians, 100,000 radiologic (X-ray) technicians, 50,000 respiratory therapists, and 45,000 medical records keepers. (This list doesn't include areas such as dental and optometric technicians who are described in other modules.) Most of these career fields are expected to grow more rapidly than many other careers as the population ages and needs the services, as new technologies are developed, and as medical insurance plans (either public or private) become more widespread.

Training in each of these areas is often available on the job, in vocational schools, and in the armed services. However, as each field becomes more specialized and in order to advance within the field, more and more training is required. Many health technical areas are moving toward or already require an undergraduate degree. All of the specialties require a study of science and increasingly mathematics is an important prerequisite.

Nursing careers account for over half of all health career workers, and this is a field where strong employment needs appear to exist. There are 1,050,000 registered nurses, 518,000 licensed practical nurses, and 1,040,000 nurses aides, orderlies, and related attendants. Nurses are the primary providers of health care. They monitor and record the vital signs of patients, provide medication, assist in rehabilitation programs, advise patients and family on health maintenance, and provide a healthy atmosphere that promotes recovery. Nurses work in hospitals, doctors' offices, private homes, community health facilities, nursing homes, industries, and schools. In many of these settings nurses are taking on more duties. For instance, in some schools nurses are teaching health concepts and skills and in doctors' offices they are performing more of the basic diagnosis and prescription of treatment. In this latter situation, with specialized training, they are known as nurse practitioners or physician's assistants or associates. Nurses' training is provided in a number of settings (e.g., through hospitals, colleges, or combinations of the two) and for three to five years. Some programs allow time for work while the training is continued. As with all health career areas, continuing education in the latest techniques is a hallmark of the field.

Licensed practical nurses provide much of the patients' bedside care, bathing, feeding, assisting in therapy, and so forth. Training can be provided in vocational schools, hospitals, or the armed services and usually lasts for one year following high school graduation. Nurses aides, orderlies, and attendents also devote most of their time to patient care, but their training is limited to on-the-job training. High school graduation is usually preferred but is not always required.

Related Activities:

See *Fit N' Trim*.

Career Information:

Allen, Anne S. *Introduction to Health Professions*. St. Louis: C.V. Mosby, 1976.

Carallaro, Ann. *Physician's Associate*. New York: Thomas Nelson. 1978.

COMETS Profiles:

Elfrieda Irving: Nurse.

This Profile provides an insight into nursing and into the life of an American Indian woman.

Sharon and Karan Baucom, Joan Brunfeldt, Grace Ketterman, Carol Moddrell, and Val Visser.

Each Profile provides a look at a different specialty in medicine - gynecology, pediatrics, internal medicine, psychiatry, pathology, and neonatology, respectively.

For More Career Information Write:

American Association of Radiologic Technicians, 645 North Michigan Avenue, Chicago, Illinois 60611.

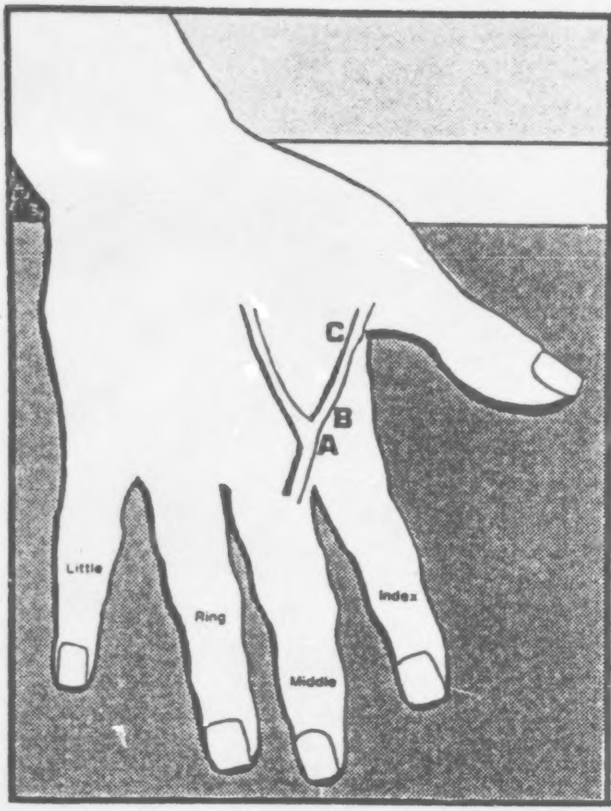
American Medical Association, 535 North Dearborn Street, Chicago, Illinois 60611. (Ask for *Education for Allied Health Careers*.)

Career Information Services, National League for Nursing, 10 Columbus Circle, New York, New York 10009.

National Association of Emergency Medical Technicians, P. O. Box 334, Newton Highlands, Massachusetts 02161.

National Federation of Licensed Practical Nurses, 250 West 57th Street, New York, New York 10019.

Society of Nuclear Medicine Technicians, 1210 Wakegan Road, Glenview, Illinois 60025.



COMETS Challenge Card

Let your right hand hang down relaxed. Bend over and find the blood vessel shown in the illustration. (Some people may find the vessel too deep to find easily, and should observe someone else's).

Observation 1. Press on A with left middle finger. Observe the blood vessel's shape. 👁 Any change?

Observation 2. Press down at B with left index finger while still pressing at A with middle finger. Slide the index finger from B to C and leave both fingers in place. Observe the vessel. 👁

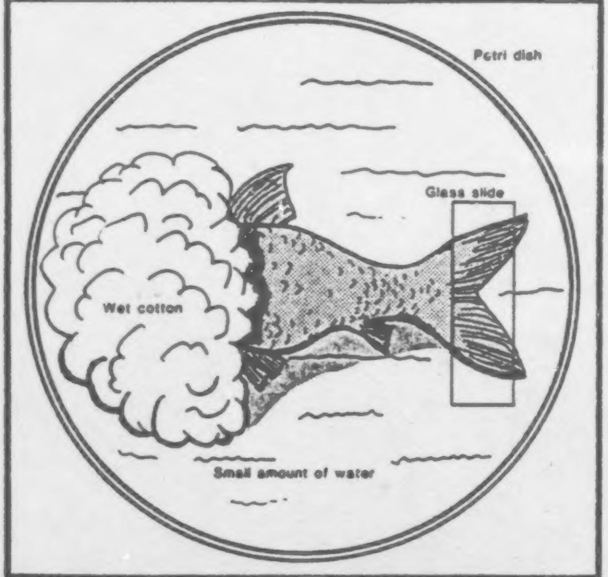
Observation 3. While continuing to press at A lift your index finger from C. Observe vessel. 👁

Observation 4. Finally lift your finger from A and observe. 👁

Healing Techniques

Questions: What can you figure out about your circulation from these observations? Which way does the blood flow?

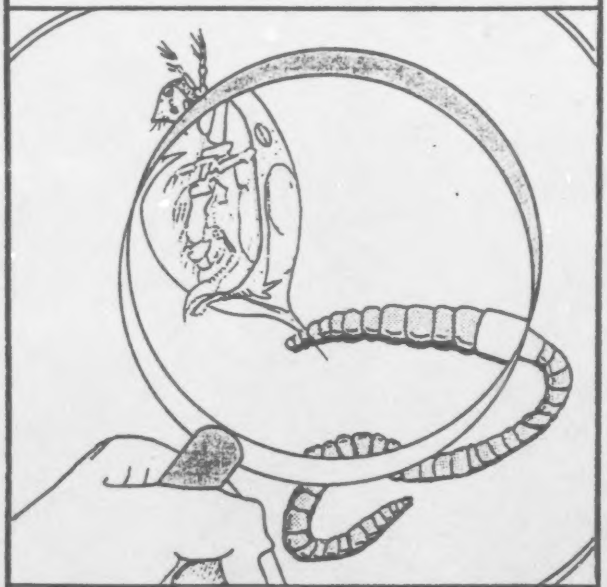
COMETS Challenge Card



Healing Techniques

Observe a goldfish's fin under a microscope. What evidence of circulation do you find? Return the fish to its water when done observing.

COMETS Challenge Card



Healing Techniques

Does circulation occur in invertebrates? Observe the daphnia with a hand lens or low-power microscope. Observe the earthworm's top side. Return them to their living areas.

Career Oriented Modules to Explore Topics in Science

TOPICS

- Food
- Chemistry
- Air Pressure

Household Science

RESOURCE PEOPLE

- Extension Agent
- Dietician
- Home Economics Teacher

THIS MODULE

Activity I

"Baking" is a series of activities dealing with the fermentation process by which yeast makes carbon dioxide (which is trapped in bread dough) and the expansion of air when heated (which happens as the dough is baked). Generally available equipment is needed. The activities can be made brief but would be enhanced by allowing more time. Anyone trained in home economics could serve as a resource person. Challenge Cards are one of four extension activities.

Activity II

Rayon is produced in "Making Fabric." The process does not take too much time, if the materials are prepared before class; but the materials may have to be gathered from a high school science department. Since some potentially dangerous chemicals are used, the activity should be done as a demonstration. Wanda K. Farr's discovery of how plants manufacture cellulose can be related, since cellulose is an ingredient in rayon. This module is especially appropriate for resource people in fabrics and textiles and/or who use chemistry in their work.

Activity III

In "Natural Dyes" students dye cloth, using water extracts of plant parts as a source of color just as our ancestors dyed cloth. This activity fits well in a study of plants or chemistry, since this is an example of applied chemistry using plants. Some plants will be easier to find than others, but at least some plants should be available to all. The remainder of the materials is generally available. Resource people in fabrics could lead this activity.

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RELATED MODULES

Household Science is intended to provide a vehicle to use home economics extension agents and teachers, dieticians, and others trained in home economics, a field with a heavy dependence on science in all branches. The following modules may also be used by resource people in home economics careers.

People Watchers

Students make sociograms and conduct a learning experiment which can be used by people in child development careers.

Body Detectives

An acid-base indicator, red cabbage juice, is studied and can be applied by resource people in foods.

Pharmacy

Especially the activity where students study antiseptics would be appropriate for career people concerned with hygiene and health.

WHERE TO FIND RESOURCE PEOPLE

Contact the county extension agent listed in the yellow pages. Dieticians can be found wherever institutional food is prepared; such places include hospitals, schools, nursing homes, large industries, and college residence halls. Contact food processors and textile manufacturers, if available in the community. High school home economics teachers should be considered. Public utilities such as the gas or electric company may employ food specialists. Contact a university or vocational school offering coursework in home economics.

Women and Home Economics

Home economics is so stereotyped as a woman's profession that "she" and "her" frequently are chosen as generic, indefinite pronouns when referring to home economists, just as "she" and "her" are often used to refer to elementary teachers, secretaries, and airline attendants. Thus, there's no surprise that women have been prominent in the development of home economics. What may be more surprising is the importance of science training for all home economists and the role science has played in developments in home economics.

Ellen Swallow Richards (1842-1911) developed the science of home economics and served as the founder and first president of the American Home Economics Association (just as she also was a co-founder of the organization which evolved into the American Association of University Women and as she also can be considered one of many founders of the science of ecology). She was trained in chemistry at Vassar and Massachusetts Institute of Technology before embarking on a truly notable and varied career. Early in her career she studied problems of sewage, water supply, and stream pollution; and this led to studies of air quality. (Her work in this area qualifies her as a founder of ecology.)

From this early work in chemistry applied to the environment (i.e., ecology), she turned to food quality and nutrition. She was especially interested in good diet, hygienic food preparation, and economical use of foods, particularly among the poor. In addition to research, she also taught these subjects, wrote extensively, and applied her ideas to social problems. For example, she helped found the first school lunch program in Boston. Almost as a sideline, she did work in metals and in industrial engineering. A partial list of her books indicates the breadth of her interests: Food Materials and Their Adulteration (i.e., their preparation), Air, Water and Food: From a Sanitary Standpoint, The Cost of Living as Modified by Sanitary Science, and The Cost of Cleanliness: A Twentieth Century Problem. Her work in nutrition can be related to Activity I; and her work in chemistry, to Activities II and III.

Alice Stoll and Giuliana Cavagelieri Tesoro, in the tradition of Ellen Richard's concern with the environment's effect on people, focused their work on fabrics. Alice Stoll developed a method to analyze the amount of heat transferred by flame contact, which served as a basis for work on the prevention of burns from burning clothes and as a means for rating clothes' ability to protect humans from thermal pain and blister. Her work was initially intended for military application, but the results are more generalizable (see Misc. Materials for an activity studying heat transfer). Giuliana Tesoro's work with fabrics ranged from the development of flame resistant fabrics to the invention of anti-static, synthetic fibers (and from advertisements and experience we all know about "static cling"!) and improved permanent press fabrics (which we all appreciate). The chemical engineering work of Stoll and Tesoro can be related to making rayon in Activity II.

Also in connection with the production of synthetic fibers, the work of Wanda K. Farr can be mentioned. For decades scientists had known that starch was produced by the chloroplasts in plant cells; but the production of cellulose, the primary structural material in plants and the material used in making rayon and other synthetics, was a mystery. This mystery was largely an optical accident. The chloroplasts, which contain chlorophyll, are green and thus rather easily visible under the microscope. However, the plastids which produce cellulose have an index of refraction nearly identical to that of water. Thus, when the cells were observed under a microscope in a drop of water (the usual technique), those plastids were invisible, because they bent (refracted) light to almost exactly the same degree as water. While conducting a thorough study of cotton, the fibers of which are composed of cellulose, Wanda K. Farr decided to microscopically observe the cells in a suspension of cotton cell protoplasm rather than in a drop of water. Although the protoplasm was primarily water, its optical properties were sufficiently different than water so that the heretofore hidden plastids could stand out. The cell's point of manufacturing cellulose had been found (see Light and Sight for an activity about refraction).

P

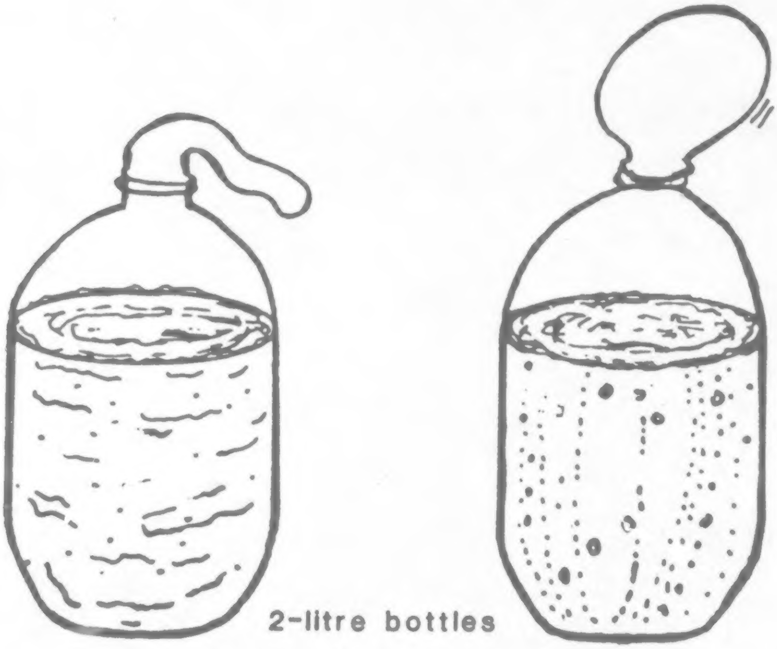
Activity I: Baking

Materials:

- Two pop bottles (e.g., plastic one or two liter bottles).
- Water.
- Sugar.
- Yeast (cake or dry).
- Balloon.

Procedure:

This activity could be done as a demonstration or by an individual or groups of students using smaller pop bottles and less ingredients. If the resource person desires a brief activity to begin a classroom visit, this activity could be used.



About 30 minutes prior to starting the classroom activity, fill two pop bottles halfway with tepid sugar water (e.g., about a half cup of sugar to one liter of water). To one bottle add a packet or a crumbled cake of yeast and shake the bottle to mix. Cap each bottle with a flaccid balloon. When starting the demonstration, show students first the bottle without yeast and then the one with yeast, which should be producing bubbles; and its balloon should be filling with gas. Point out that if the yeast and sugar water had been in bread instead of in a bottle, the gas would have been trapped in the dough. The resource person can then move to career applications of this concept or to one of the extension activities.

Extension Activity I: Expanding Gas

Materials:

- Bottle with opening about 3/4 - 1" in diameter (so egg can just sit in it without falling through).
- Peeled, hardboiled egg.
- Newspaper.
- Matches.

Procedure:

Dough rises as yeast produces gas (CO_2), but the dough also rises further during baking as the trapped gas bubbles are expanded by heat. This classic, egg-in-the-bottle demonstration shows the effect of heat on gas. With a little flamboyance, extra drama can be added to these directions.

Place the peeled, hardboiled egg on the opening to the bottle and ask how the egg can be gotten into the jar without your pushing on it. If the assumption is correct that you are teaching a new concept, then don't expect too many answers. Advise the students to watch carefully what happens. (See illustration on page 7.)

Force the egg into the jar by dropping a small, burning piece of newspaper into the jar and quickly replacing the egg on the opening. The egg should jiggle a little (as the heated and thus expanding air escapes). Very shortly after the paper fire dies out, the egg should plop into the bottle, because as the air in the bottle cools, it exerts less pressure. Thus, the inside pressure becomes increasingly less than the outside pressure (note that air can't get into the jar because the egg acts as a one-way valve that allows air out but not in). Soon there's enough difference in air pressure that the egg is forced into the jar.

Ask students for their observations. What did they see you do and what did they see the egg do? In what sequence did they make these observations? How might these observations be explained? Students should be able to figure out the idea that warm air expands (unless it's in a container which does not

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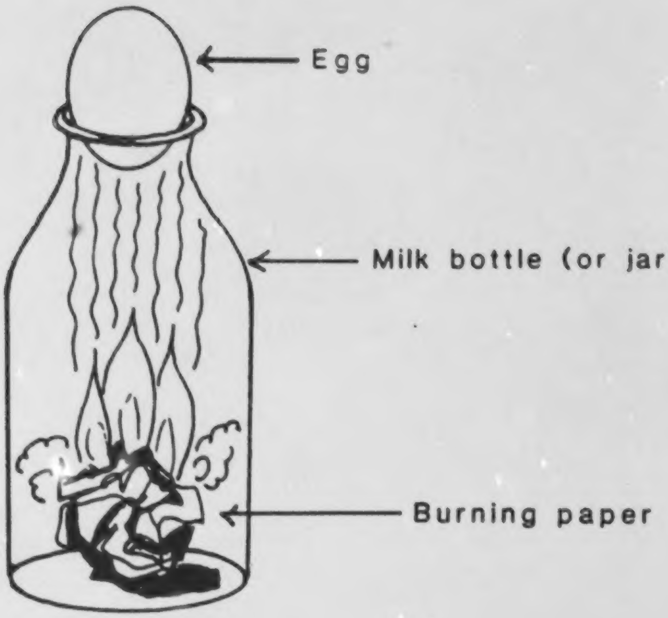


allow this expansion, in which case the air pressure increases) and cool air contracts (unless it's in a container which does not contract, in which case the air pressure decreases).

After the students have arrived at an explanation for their observations, ask them to devise a way to get the egg out of the bottle. They should have more suggestions this time, and they should apply the concept just learned. In some way the air inside the bottle needs to be heated with the bottle upside down and the egg in the opening, again acting as a one-way valve. Air could be heated with burning paper again, or by holding a candle under the side of the bottle with the bottle tilted slightly, or by running hot water over the bottle.

An alternative technique which students love to watch, but which unfortunately doesn't demonstrate the heating and cooling of air, is for the teacher to hold the bottle to the teacher's mouth. The bottle should be upside down with the egg in the opening (again, the one-way valve). By blowing vigorously into the bottle and then quickly taking the bottle from the lips, the compressed air in the jar will force the egg out. Students love to watch, since the teacher usually has to scramble after the expelled egg to prevent a bit of a mess.

P

Back to the heating idea. Heating the jar to expel the egg can be related to heating the dough during baking. The heated air in the jar or in the dough expands.

Extension Activity II: Quantifying Gas Production

Materials:

- Same materials as for Activity I, plus:
- Measuring tape.
- Various juices (e.g., grape, tomato, orange, etc.).
- Watch or clock.

Procedure:

Students can experiment with gas production by yeast, using one or a combination of independent variables, such as amount of yeast, type of juice, or temperature of the environment in which the gas production bottle is placed. This extension activity probably should be done following the resource person's visit.

The quantity of gas produced can be roughly estimated by measuring the circumference of an approximately spherical balloon and using the formulas:

(1) Circumference = $C = 2\pi r$ → Thus, $r = \frac{C}{2\pi}$

(2) Volume = $\frac{4}{3}\pi r^3$

Plugging the value for r from the first equation into the second:

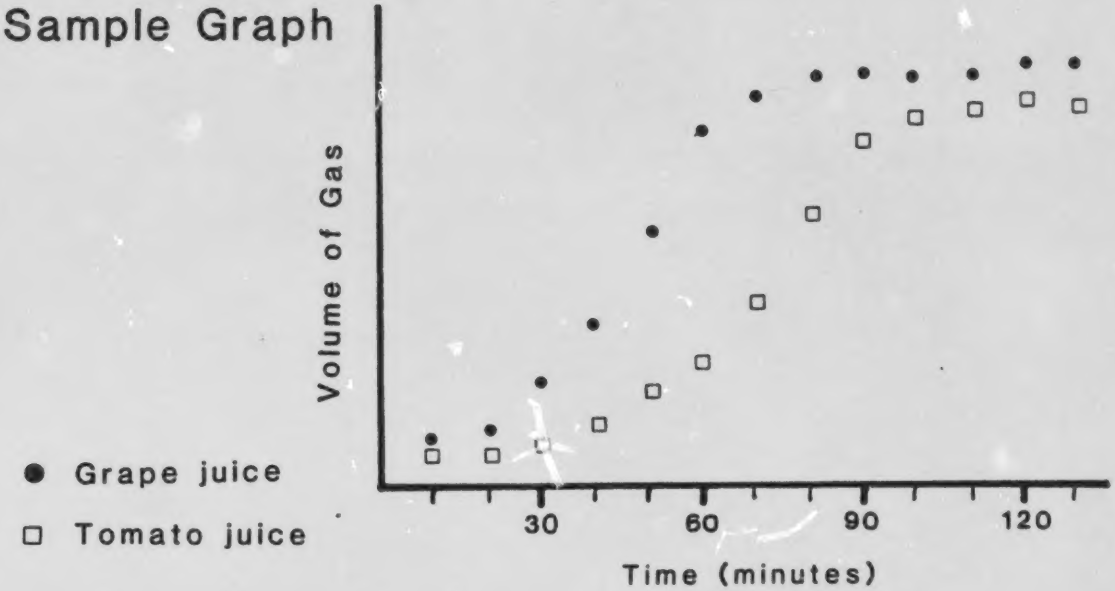
$$\text{Volume} = \frac{4}{3}\pi\left(\frac{C}{2\pi}\right)^3 = \frac{4}{3}\pi\left(\frac{C^3}{8\pi^3}\right) = \frac{C^3}{6\pi^2}$$

The value of $1/6\pi^2 = .0169$ Thus, volume = $\frac{C^3}{6\pi^2} = .0169\ (C^3)$

Thus, when students measure the balloon's circumference, they can compute its approximate volume using the above formula. For example, if the balloon's circumference were nine inches:

Volume = $.0169\ (9\text{ inches})^3 = .0169\ (729\text{ cubic inches}) = 12.3\ \text{in}^3$

The circumference of the balloon could be measured each ten minutes and the results graphed as in the illustration on page 9.



Sample Graph

Extension Activity III: Fermentation Applied

Materials:

- Bottles with openings wide enough to add ingredients but narrow enough to cap with balloons.
- Grass clippings or other compost.
- Dirt.
- Balloons.
- Thermos bottle with cork for opening.
- Thermometer which can fit into the thermos.
- Flour.
- Sugar.
- Water.
- Yeast.
- Challenge Cards (optional).

Procedure:

These Challenge Cards activities could follow the resource person's visit or individual ones could be used by particular resource people. For example, the yeast activity could be used by a resource person who works with baking. The Challenge Cards and/or the directions could be given singly or together to students.

The card which compares sprinkled yeast and mixed yeast shows how the gas (CO_2) produced by the yeast is trapped in the dough with mixed yeast. In that bottle the dough will rise and the balloon will remain flaccid. In the other bottle with yeast sprinkled on top of the yeast, the dough will not rise but the balloon will begin to fill.

In the bottle filled with compost, the flaccid balloon will begin to fill with gas and odors of fermentation can be observed. Probably you will want to simply discard the bottles and contents of this and the preceding card when you are done with the activity, since clean-up would be so messy.

The Challenge Card showing the thermos bottle demonstrates that heat and alcohol are products of fermentation. The alcohol can be detected by its odor. The heat production can be measured by placing a thermometer periodically into the thermos bottle. The cork should be loose enough, so that any built-up air pressure would pop the cork before the bottle exploded. The periodic temperature readings will allow the gas to be released, so explosion is not a great danger. Temperature readings can be recorded throughout the day.

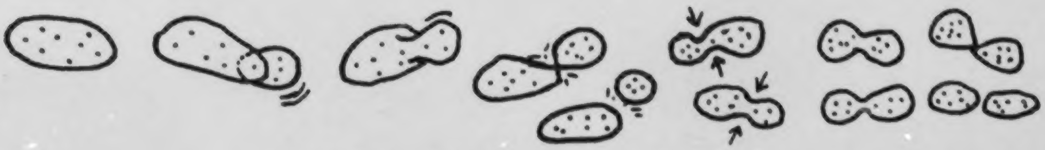
Extension Activity IV: Yeast

Materials:

- Dry or cake yeast.
- Water.
- Microscope slide.
- Dropper.
- Microscope or microprojector.

Procedure:

This brief activity allows students to observe yeast budding and to conclude that yeast is alive. Mix the dry or crumbled cake of yeast in a half cup of tepid water. Put it aside for five to ten minutes and then place a drop of the solution on the slide under the microscope. Observe the yeast reproducing asexually by budding.

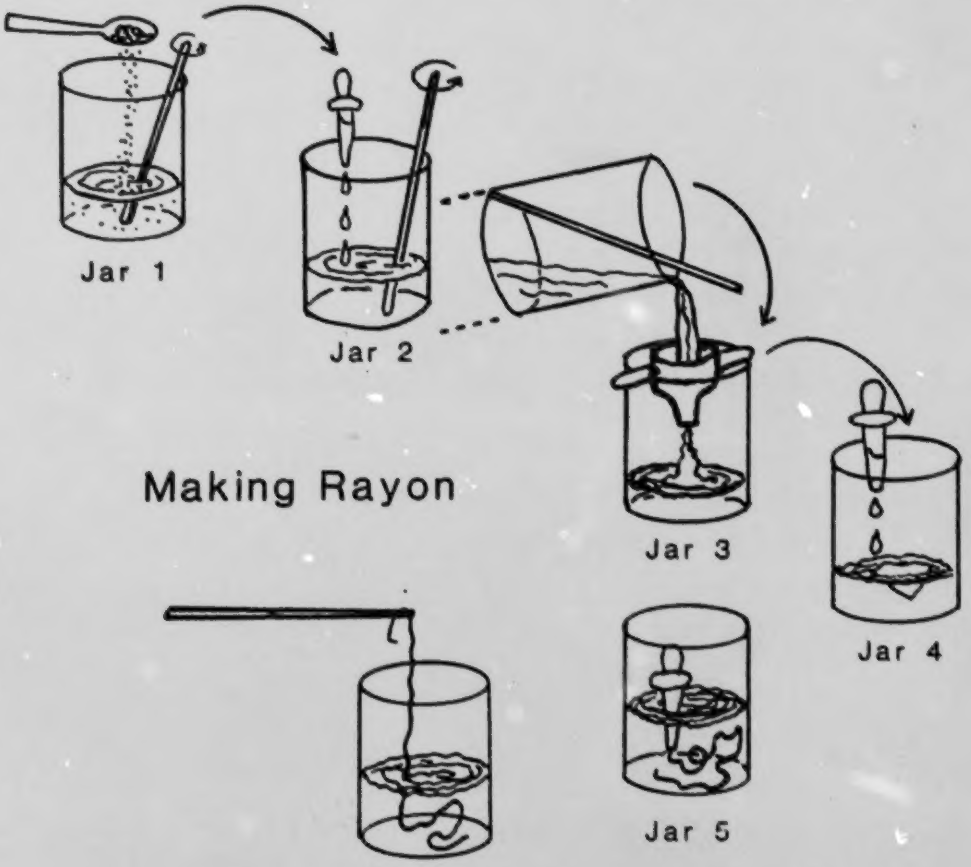


Yeast budding by division

Activity II: Making Fabric

Materials:

- Concentrated ammonium hydroxide (NH_4OH) solution.
- Copper sulfate crystals ($CuSO_4$).
- Dilute sulfuric acid (H_2SO_4).
- Water.
- Glass stirring rod.
- Tablespoon.
- Glass funnel.
- Filter paper (could use a coffee filter).
- Eyedropper.
- Five pint jars.



Making Rayon

P

Procedure:

Because of the potential danger of this activity, it should be done as a demonstration unless students are quite adept at properly handling chemicals. Refer to the illustration on page 11.

Rayon, a synthetic fiber, can be made in the following manner. Fill a pint jar one-fourth full of water and add crushed copper sulfate, while stirring, until no more will dissolve. Pour the liquid into a second jar, leaving any excess solid $CuSO_4$ in the first jar. To the liquid in Jar 2 add ammonium hydroxide drop by drop and stir until a light blue color appears. (If the solution becomes dark blue, start over again.)

When the ammonium hydroxide ceases to make the solution any lighter, pour the liquid through a glass funnel lined with filter paper into a third jar. This liquid can be discarded. Next, put the filter and its contents into a fourth jar. Add just enough concentrated ammonium hydroxide to dissolve the filter paper. A thick blue jelly-like substance called a cellulose sol should form. (Cellulose is the basic ingredient of paper.)

Pour 11 tablespoons of dilute sulfuric acid into the fifth jar. With the cleaned eyedropper squirt the blue, cellulose sol solution from the fourth jar into the fifth jar with dilute sulfuric acid, holding the tip of the dropper below the surface as you squirt. The cellulose sol will react with the sulfuric acid to form threads of rayon, which can be removed with the glass stirring rod, gently washed, dried, and examined.

The work of Wanda K. Farr in uncovering the structure of cellulose can be related while the liquid is draining through the filter paper and there is a little time for her story.

Activity III: Natural Dyes

Materials:

- Hot plate.
- Food strainer.
- Iron for pressing cloth (optional).
- Enamel or glass pot.
- Variety of white fabrics, cotton, rayon, nylon, linen, and/or wool, cut into uniformly-sized pieces (about 3" x 3", for example) and well washed.
- Sample of fruits, vegetables, or parts of trees, as available from this list:
    - Light brown, yellow, and orange from onion skins, roots of white mulberry, wood from sumac, roots from osage orange (hedgeapple), or carrots.
    - Green from spinach.
    - Rose from beets, pokeweed berries, or roots from dogwood.
    - Gold from goldenrod flowers.
    - Brown from coffee or hulls of black walnuts.
    - Red from red sumac berries, bloodroot roots, or red raspberries.
    - Black from red sumac leaves.
    - Blue from red maple or blue ash bark, or blueberries.
    - Purple from red cedar roots.

Procedure:

This activity takes some time, so it could be started prior to the resource person's visit or demonstrated during the visit and completed later. This activity duplicates the procedures used by our pioneers.

Chop leaves, grind roots and stems, and/or crush berries. Soak the plant parts overnight in enough water to cover. Boil the water and contents slowly for an hour in an enamel or glass pot. Then strain the dye, removing the plant material.

Dip the cloth fabric samples in water and wring them out. Put them in the dye bath, cover, and simmer slowly until the desired color is obtained. The color will lighten as it dries. Let the cloth almost dry and then iron it smooth, if desired. Since these dyes are water soluble, they will wash out, so caution students not to add these fabrics to the wash at home.

P

Career Information

After completing four years of college, dieticians work in food preparation for large groups in schools, hospitals, large industrial plants, and so forth. The work of some dieticians emphasizes managing a large production operation; others emphasize consulting individuals on proper nutrition; and still others work in research. Collegiate training of these 35,000 dieticians includes chemistry, foods and nutrition, physiology, and bacteriology. Another 15,000 collegiately-trained people in food technology work in food processing, packaging, distribution, research and development, and quality control. While dieticians focus on preparing food at or near its point of consumption, food technologists focus on the initial commercial processing and packaging of food at or near its point of production.

Home economics extension agents and home economics teachers devote most of their efforts to education of either adolescents or adults. Extension agents, of whom there are 16,000 in all facets of extension work, are employed mutually by the federal Department of Agriculture and the state's land grant university. The majority work at the county level, but some work at the regional or state levels. Agents advise individuals or groups about new techniques and laws or arrange for people to get the information they need, and they organize youth activities (primarily through 4-H).

Related Activities:

Cobb, Vicki. Science Experiments You Can Eat, 1972; and More Science Experiments You Can Eat, 1979. Philadelphia: Lippincott.

Corona, Philip B. Chemistry and Cooking. Englewood Cliffs, N.J.: Prentice Hall, 1975.

Lesch, Alma. Vegetable Dyeing. New York: Watson-Guptill, 1970.

COMETS Profiles:

Carol Sanders: Dietician.
Her varied career has led now to teaching in a vocational school.

For More Career Information Write:

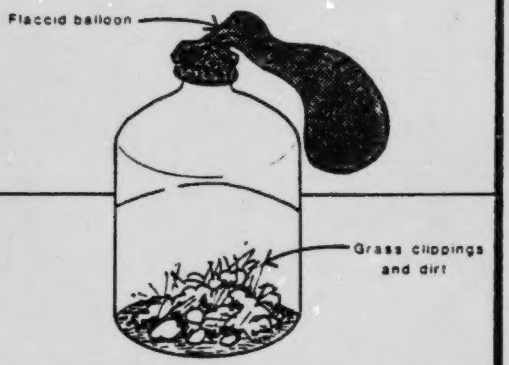
American Home Economics Association, 2010 Massachusetts Ave., Washington, D.C. 20036.

American Institute of Nutrition, 9650 Rockville Pike, Bethesda, MD 20014.

Extension Service, Department of Agriculture, Washington, D.C. 20250.

Home Economics Education Association, 1201 16th Street, N.W., Washington, D.C. 20036.

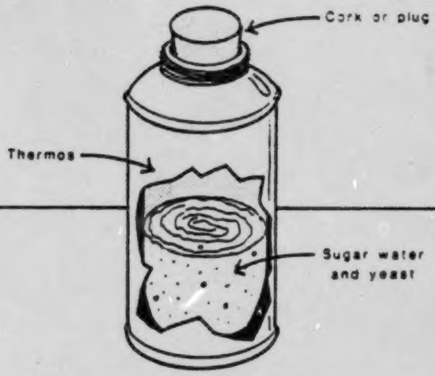
COMETS Challenge Card


Flaccid balloon
Grass clippings and dirt

Household Science

Fill a plastic bottle with grass clippings mixed with a couple spoonfuls of dirt. Cap bottle with a limp balloon. Set aside and observe for several days. Any signs of fermentation?

COMETS Challenge Card


Cork or plug
Thermos
Sugar water and yeast

Household Science

Fill a thermos halfway with sugar water and yeast at room temperatue. Measure temperature, and cap. Check temperature every two hours. Smell contents. What products besides carbon dioxide are being made?

COMETS Challenge Card

Make a thick paste of flour, sugar, and water. Divide into 2 equal portions. Mix yeast in one portion, add it to one jar, and cap with balloon. Add second portion to second jar, sprinkle yeast on surface of paste, and cap with balloon. Put the jars in a warm place and observe for several hours.

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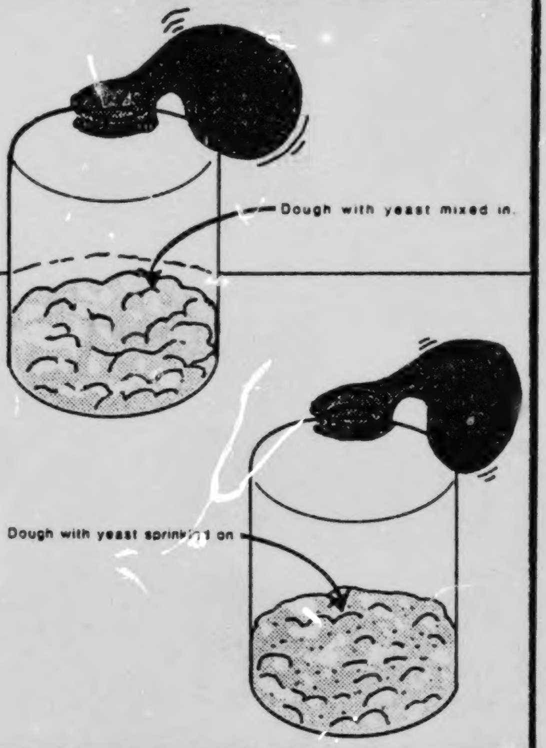
Household Science

How would you explain your results? What do your results have to do with breadmaking?


Dough with yeast mixed in.
Dough with yeast sprinkled on

Outdoor People

TOPICS	RESOURCE PEOPLE
Wildlife Ecology	Wildlife Biologist
Animal Behavior	Ethologist
Biology	Ecologist

THIS MODULE

Activity I

In "Life: An Index to Physical Conditions" students determine the temperature of their environment by measuring the frequency of cricket chirps. This activity can be completed in a short time, requires only crickets (available at pet stores) and room thermometers, and would be an appropriate activity for resource people who work with environmental indicators. Naturalists, limnologists, or environmental engineers (air or water quality specialists) would be good resource persons. Ruth Patrick's (see Fluid Follies) diatomaceous classification as an index for stream water quality can be recounted here, as can the major points in Rachel Carson's Silent Spring.

Activity II

In "Tracking, Trekking" students mark grasshoppers for a capture-recapture study to determine the total population of grasshoppers on their school grounds. It takes several days to complete this activity and some special equipment such as sweep nets is desirable. Resource people (wildlife biologists or animal behaviorists would be good choices) could relate their work with animal populations either before or after students complete this activity. The work of an ethologist, Jane Goodall (chimpanzees), or a wildlife biologist, Frances Hamerstrom (prairie chickens), can be recounted here. Both have spent many years in field investigations researching and writing about the natural histories of their favorites. Karen Meier's work tracking opposums with radio transmitters could also be presented here.

Activity III

"Dating Changes" discusses methods for describing environmental conditions of the past. Students take tree cores with an increment borer and decipher the environmental history of the area. The extension activity, "Changing: Seeing is Believing," requires live material, preserved forms, or pictures of various post-embryonic stages of different insects to enable students to match youthful forms (larval, nymphal) with adults. Either of these activites could be brief. For example, a forester could bring a variety of tree cores and have students match weather data to the tree cores; or an entomologist could bring insect specimens in different developmental stages. If the teacher conducts either of these activities, advance preparation of specimens, equipment, and miscellaneous information (such as local weather data available from the National Climatic Center) is necessary. These activities are most appropriately used in learning centers.

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RELATED MODULES

People who work with natural resource agencies would make good resource people for this module. Naturalists, limnologists, foresters, animal behaviorists and wildlife biologists could work with any of the described activities and could heighten the intended educational experiences by sharing the results of some of their own field investigations. Natural resource specialists could also work with the following modules.

Fluid Follies

In "Hay Infusion" students study aquatic microorganisms. This activity could be expanded to include a study of indicator specimens in aquatic habitats.

Soil

In "Life in the Dirt" students make and use a Berlese funnel to sample soil life. Mite species prefer specific habitat types and are therefore excellent indicator species. It might be easier to work with other soil invertebrates, however, as most mites are microscopic and difficult to identify.

Chances Are

Many statisticians work in the natural resource area predicting population rises and declines. Wildlife biostatisticians must make accurate predictions in order to allow an area to be effectively managed and its wildlife resources harvested by hunters, fishers, and trappers. Natural resource statisticians could work with this module also.

WHERE TO FIND RESOURCE PEOPLE

Contact state and federal resource agencies such as the Soil Conservation Service, the Geological Survey, the Fish and Wildlife Service, the Forest Service, the Department of Conservation, the Department of Health and Environment, and the Biological Survey. Look in the yellow pages under federal, state, and local government to locate natural resource agencies in your community. Some public school systems have an environmental education staff. Local chapters of the National Audubon Society, the Nature Conservancy, the National Speleological Society, and other conservation groups are likely to have naturalists among their memberships. Contact outdoor stores which sell hiking gear. A librarian could refer you to people who borrow books about nature or outdoor activities like hiking, canoeing, and backpacking. Natural History Museum employees would be able to relate their work to the activities in this module.

Women and Wildlife

Many women are engaged in environmental science. Women are working as wildlife refuge managers, environmental engineers, hydrologists, ethologists, ecologists, conservation officers, university professors, and wildlife biologists. While there are not numerous women in some of these professions, more and more women are opting to become outdoor people.

Rachel Carson (1907 - 1964) was the forerunner of the environmental movement. She first alerted the American public to the dangers of pesticides, which cause degradation of the environment, in her controversial best seller, Silent Spring (Greenwich, Connecticut: Fawcett Publications, 1962). In her warning of the reckless and irresponsible poisoning of the world, she told "A Fable of Tommorrow." She painted a beautiful picture of an idyllic town only to have some strange blight, some evil spell creep over the land. The farm animals die, the farm families die, the birds are gone. The few birds that are seen tremble violently and cannot fly. "It was a spring without voices . . . only silence lay over the fields and woods and marsh . . . the streams are now lifeless." What brought that shadow of death? A white granular powder, DDT, had fallen like snow some weeks before upon the roofs and lawns and fields and streams.

Carson's work can be related to Activity I, "Life: An Index to Physical Conditions." Just as the frequency of cricket chirps gives an indication of the surrounding temperature, and just as the presence or absence of certain diatoms or lichens gives some indication of water and air quality, so the presence of sick animals signals a sick environment. Wildlife can be a thermometer of environmental conditions and with it one can chart the fevers of environmental sickenss. (See Fluid Follies for information about Ruth Patrick, a limnologist who studies stream life.)

Olga Huchins, Carson's friend, asked Carson to find out why her birds had died after her yard was sprayed with DDT as a part of Massachusett's mosquito control program. In Silent Spring Carson documented the environmental disasters perpetrated by the unwise, indiscriminant use of pesticides and urged that more research be undertaken to enable pesticides to be used safely and find alternative techniques for pesticide control. Some effects of indiscriminant pesticide use are (1) eggshell thinning in bird species such as ospreys and brown pelicans, (2) death of non-targeted animal groups such as owls and fish, and (3) development of resistance through natural selection in pest populations, resulting in pest population booms and even greater crop destruction.

While some researchers must conduct extensive chemical analyses in the lab as well as make observations in the field, other researchers spend nearly all of their time in the field. For these women, keeping track of research animals becomes a challenge. Karen Meier, a graduate student at Oregon State University, is using radio transmitters to track opposums, while Nicole Duplaix wore a rubber otter mask in an attempt to swim close to the giant river otters that she was observing in South America. Jane Goodall (chimpanzees), Dian Fossey (gorillas), and Birute Galdikas (orangutans) have spent so many hours in the field observing primates that they identify these creatures just as we identify an acquaintance by appearance and voice. Goodall, Fossey, Duplaix, and Galdikas have been featured in National Geographic articles. These articles make good reading and sources of student reports (see bibliography). Relate the work of these wildlife biologists to Activity II, "Tracking, Trekking."

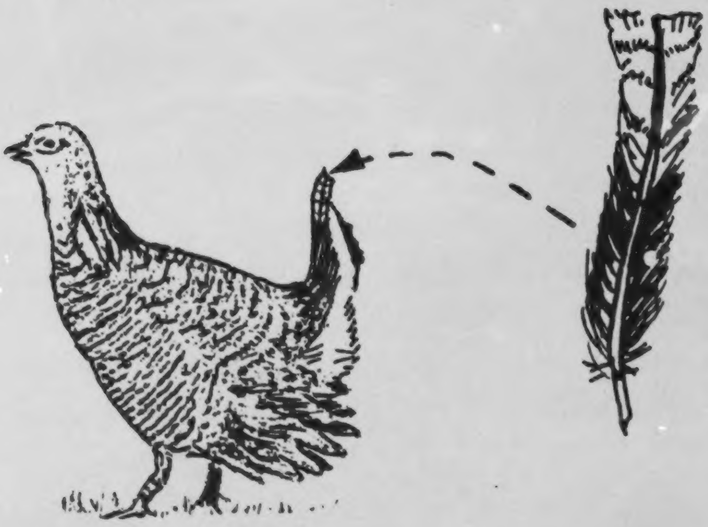
Dr. Frances Hamerstrom imagines that she has risen from bed before 3 a.m. more than a thousand times. That is because she is a wildlife biologist and for the last forty-some years she and her husband, Dr. Frederick Hamerstrom, have studied the greater prairie chicken which now thrives on central Wisconsin's wet prairies.

In the 1930's Frances Hamerstrom traded life in Boston as a fashion model for life in central Wisconsin as a wildlife biologist. She and her husband ('Hammy' to her) came to study the then nearly extinct prairie chicken. A prairie chicken is an 18" long, buffy brown grouse with barred underparts and a short tail and weighing nearly two pounds. Prairie chickens spend most of their time on the ground and prefer wet prairie habitats. In the 1930's in central Wisconsin the wet prairies were being drained and turned to agricultural use. With little suitable habitat remaining, the greater prairie chickens were in danger.

According to Frances Hamerstrom, they came to Wisconsin to see that "wildlife would be managed so the sandhill cranes (then rare) would trumpet over the marshes each spring, the prairie chickens would boom in the early mornings, the fur harvest would be planned, and the deer would be held down so they would not overbrowse their range. We tried to teach conservation." (From Strictly for the Chickens, see bibliography.)

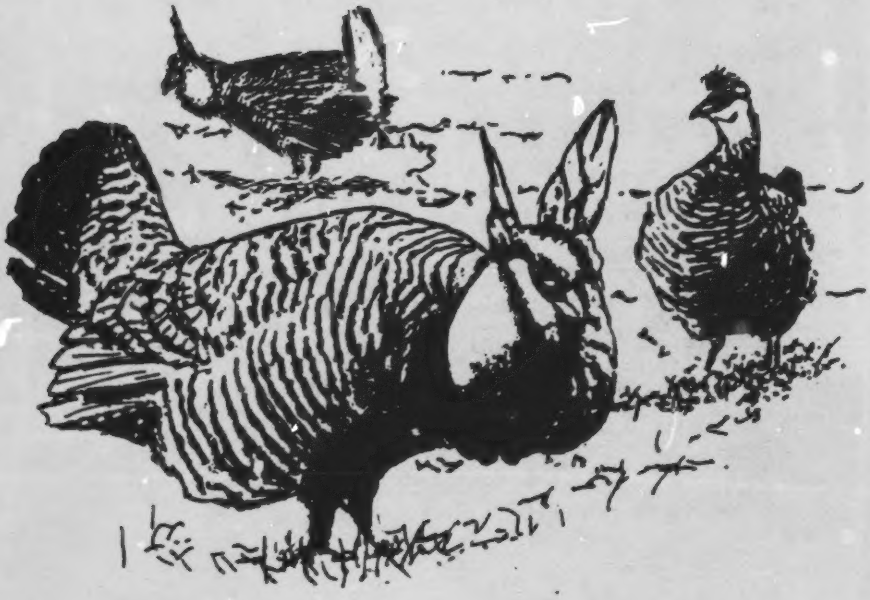
When the Hamerstroms first arrived, they had to make their own road maps of central Wisconsin. They had to devise their own blinds (at first they just lay in ditches) to observe the prairie chickens and their own traps to catch the birds so that they could be handled or marked.

The Hamerstroms used aluminum leg bands to mark the individual birds but needed something more flamboyant, so that identification would be faster when researching the natural history of the bird on its booming grounds. So . . . they saved feathers from dead blue jays and cardinals and dyed hundreds of white feathers to mark the chickens. After catching the birds they cut off a feather close to the skin but left the hollow shaft protruding. Then they dipped a new, colored feather into household cement and into the shaft. Now it was easy to identify the cocks as they paraded about doing their ritualistic dance which consists of "snoopy" jumping, inflating hugh orange air sacs on their necks, and calling (or booming) which sounds like low pitched organ music, all at the same time.



All this hoopla occurs early in the morning on their booming grounds, a place they return to each breeding season, and precedes copulation with the hens.

Q



In addition to her field work which is not limited to prairie chickens but includes birds of prey, ospreys in Mexico, and European geese, Frances Hamerstrom has written several nature books for children. These are referenced in the bibliography. After more than 40 years with the chickens, including 23 years as a game biologist with Wisconsin's Department of Natural Resources, Frances Hamerstrom has discovered a new way to track her birds. She has given them each a name, and she identifies them by their faces!

Because of the work of the Hamerstroms, there are many prairie chicken reserves in the U.S. If the bird occurs nearby, visiting the blind in early spring can be an unforgettable experience for students (and teachers).

Activity I: 👁 1234 🧪 +/-

Life: An Index to Physical Conditions

Materials:

- Crickets (tree, house, or katydids; house crickets can be purchased at most pet stores for about 7¢ apiece).
- Watch (with second hand).

Background Information:

Certain animals and plants are found in specific environments. For example, a polar bear leaves the lasting impression: cold. A cactus leaves the lasting impression: dry. There are may other common wildlife-environment associations (heron: water, crab: ocean, cattail: marsh, etc.). These broad associations do not provide us any detail, however.

Many plants and animals, though, prefer a very particular environment or niche. These organisms are called indicator species, because being found (or not found) in a very particular environment "indicates" that there are (or are not) certain attractive characteristics of that environment. For example, different species of lichens prefer habitats with different aerial constituents. Thus, lichens are good indicators of air quality. No lichens grow in very polluted air.

Ruth Patrick, a limnologist, identified different species of diatoms which are associated with different sorts of water (see Fluid Follies). One can gauge the water quality of a stream by the diatomaceous species which are present. Thus, rather than taking numerous physio-chemical measurements, one can look at diatomacous stream life to get some "indication" of the characteristics of the physical environment.

Bats are excellent indicator species in the cave environment. Certain species prefer cooler, drier habitats, while other species prefer warmer, more moist roosts. Rather than measure the humidity and temperature, one can come quite close to estimating these characteristics by identifying the bat species roosting in a particular area of the cave.

In this activity students will estimate room temperature based on the frequency of cricket chirps.

Procedure:

If possible, obtain all three organisms: tree cricket, house cricket, and katydid (although any one will do). Even if you are not a field person and not up to collecting katydids and tree crickets, house crickets can be purchased at local pet stores.

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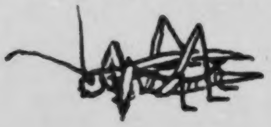
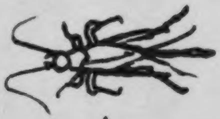
Have students guess the room temperature. Next, count cricket chirps three times for one minute each and average the chirps. Then compute the room temperature based on the following formulas:

Tree cricket



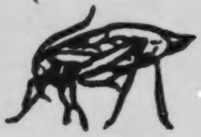
$$T = 50 + \frac{N - 90}{4.7}$$

House cricket



$$T = 50 + \frac{N - 40}{4}$$

Katydid



$$T = 50 + \frac{N - 19}{3}$$

N = Average number of chirps per minute

T = °F

Discuss your results and compare those with a room thermometer reading. For additional activities try the COMETS Challenge Cards for this module.

Resource people could conduct this activity or could come to class after students had completed this activity and share their research interests on indicator species. If resource people conduct this activity, they should briefly explain their research and then have each student count cricket chirps and work the computation on the board. They should then draw parallels between their work and the class experiment. They could hand out Challenge Cards or the teacher could use these as a follow-up to the visit.

Activity II: Tracking, Trekking

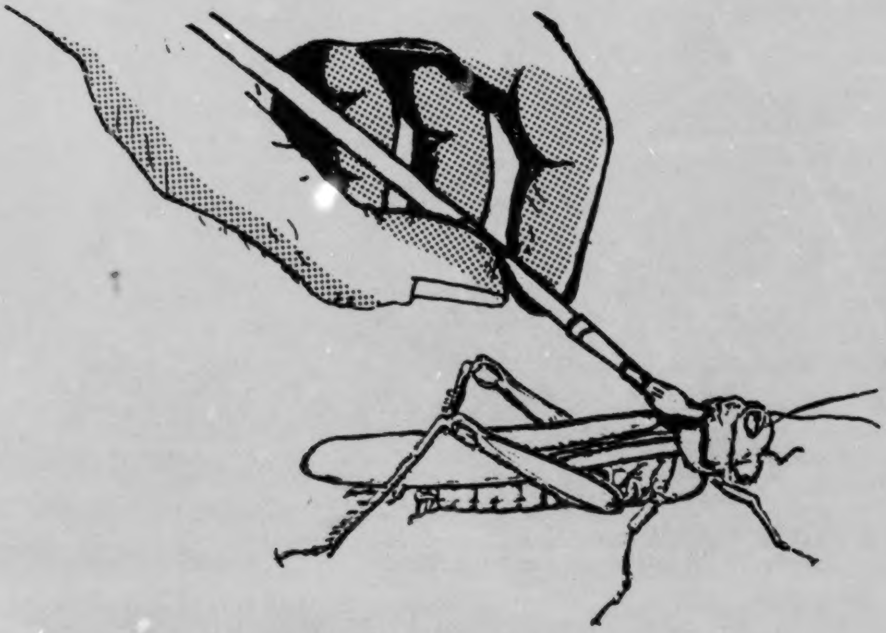
Materials:

- Sweep nets.
- Enamel paint (in small jars for models).
- Toothpicks.
- Paper and pencils.

Procedure:

Students will estimate the population of grasshoppers in the school yard, a nearby park, or someone's yard. This activity takes several days and requires little equipment, but a lot of organization. Students can be assigned to teams, the number of which depends upon the number of available sweep nets. Each person can have a turn at sweeping, marking, recording, and releasing the grasshoppers. Be sure that the students understand that in order to control extraneous variables, they should sweep for the same amount of time in the same order on both the "capture" and "recapture" days. Weather conditions and time of day should also be similar.

Before conducting your field investigation, determine the total amount of time that you will sweep, the order and time span of students' sweeping, the areas that different student teams will sweep, and a method for recording



Q

numbers of marked grasshoppers. You may also want to demonstrate sweeping techniques.

It will probably take two class periods to organize the field work, and two additional class periods to capture and recapture the grasshoppers. A final day should be spent analyzing the data, computing the Lincoln Index (population estimate), and discussing the field work (problems encountered such as variability).

In the field on the "capture" day, students will catch grasshoppers in a predetermined area with sweep nets. "Mark" each grasshopper by putting a small dab of paint on the grasshopper's thorax; and then release the grasshopper. Record this marking. On the "recapture" day students will sweep and count the marked and unmarked grasshoppers. Returning to the classroom, students can compute a population estimate using the Lincoln Index where:

$$\frac{\text{total population of grasshoppers}}{\text{number of marked grasshoppers on the "capture" day}} = \frac{\text{number of unmarked grasshoppers collected on the "recapture" day}}{\text{number of marked grasshoppers recaptured}}$$

For example, on the capture day students caught and marked 50 grasshoppers. On the recapture day students caught 70 grasshoppers. Ten of the 70 were marked but 60 were not marked. To estimate the total population (P) of grasshoppers in the school yard use the Lincoln Index ratio:

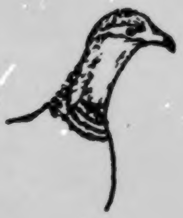
$$\frac{P}{50} = \frac{60}{10} \qquad P = \frac{(50)(60)}{10} = 300$$

To make the activity more challenging, each team of students could use a different color paint and then compute the population of grasshoppers in their assigned areas. Extended activities could revolve around plotting the movements of the grasshoppers in the same populations as evidenced by the recapture of different colored grasshoppers in different areas.

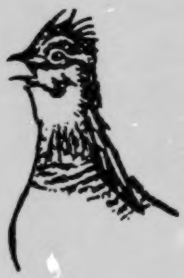
Your resource person could come to class before or after this activity. If before, they could share their experiences with different animal groups and talk about problems with sampling and statistical tests. An entomologist could demonstrate how to use the sweep nets and how to mark insects, like grasshoppers.

More Information

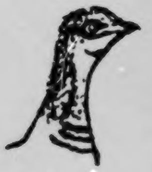
When conducting research with animals, it is often necessary to "keep tabs" on individuals. Scientists who are working with a local population often spend many first days in the field just learning to recognize individual members of a population. Dr. Frances Hamerstrom, a wildlife biologist who studies prairie chickens in central Wisconsin, has recently written a book Strictly for the Chickens (see bibliography) in which she discusses "How to Tell Chickens by Their Faces." According to Dr. Hamerstrom, "the trick is to give each bird a name." For chickens, though, the name is more a description. Compare "cock, dark quad, white back of eye and checkered necklace" with "red hair, freckles, tall, ears stick out."



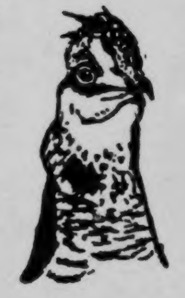
WHITE BOTH SIDES OF EYES
FAINT QUAD
PEARL NECKLACE



DARK NEAR EYES
DEEP SMOKEY QUAD
GRASSY
STREAKED NECKLACE



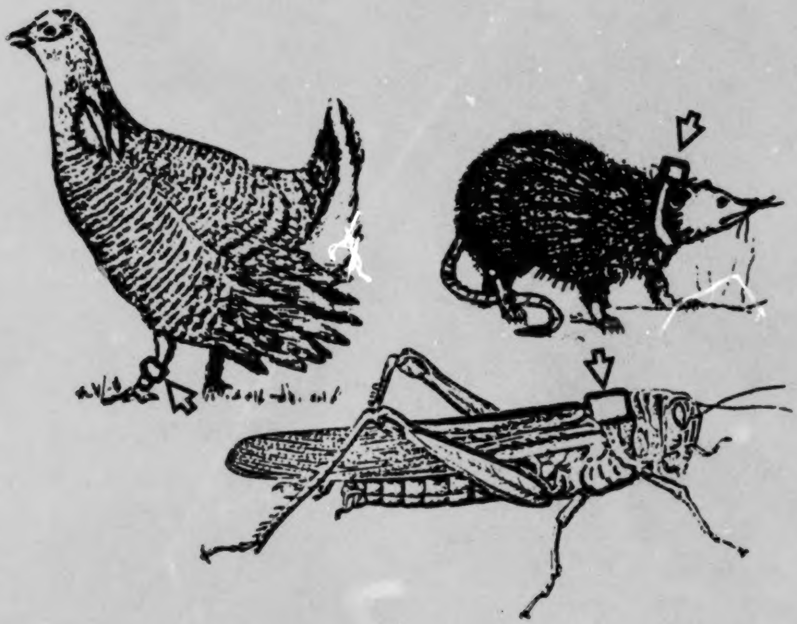
DARK NEAR EYES
DARK QUAD
DEEP NECKLACE



WHITE BEFORE EYES
FAINT LINE QUAD
NECKLACE HAS RIGHT BLOB

While names are important for animals which need to be individually identified for research on life histories and social interactions, other types of research projects require that data be collected on segments of the population. These segments of the animal population must be marked. For many types of wildlife research it is important to know not "who" the animal is but whether the animal you are looking at today is one of the animals you saw yesterday. With this kind of information one can determine migration routes, migration distances, home range, and territories. Insects, like honeybees, are often marked like grasshoppers on their thoraxes.

Some methods of marking animals are described in "Women and Wildlife." Other methods of marking mammals include fur dyeing, ear notching, and ear tagging. Toes can be clipped too. Aluminum leg bands are often used on bats and birds. Turtles can be marked by notching the scutes along the margin of the carapace (upper shell) with a triangular file. Snakes can be marked by cutting a V-shaped notch on the ventral scales near the posterior margin. Frogs have been marked with clips on the webs of their feet. Fish are tagged through the jaw, gill-cover, fin, or tail. A very thin piece of adhesive backed paper is put on hind wings to mark moths and butterflies. There are many ways to mark individuals, and research scientists are always looking for better ways to distinguish members of animal populations.



Q

Activity III: Dating Changes

Materials:

- Chart of local climatic conditions for the past 5 - 20 years. (Can be obtained from the National Climatic Center, Environmental Data Service, Federal Building, Ashville, N.C. 28801, (704) 254-0236. Cost varies depending upon your location and the amount of data requested, but usually runs between $3 and $6. Turnaround time is one to two weeks.)
- Increment borer (Can be borrowed from forestry agencies, your local extension agent, or high school science teachers. Increment borers (4" - 20") can also be purchased from forestry supply companies, but in most cases the cost would be prohibitive. The average cost of a 4' borer is $50.)
- Access to trees. (Be sure to obtain permission from tree owners. Coring is rather harmless to trees, but the increment borer should be wiped with bleach or rubbing alcohol between corings to prevent the possibility of transmitting tree diseases.)
- Ruler marked in millimeters, mm; or sixteenths of an inch.

Background Information:

Research scientists tackle many problems in which they try to sort out various pieces of information. Foresters are often concerned about the potential damage an outbreak of a pest species may cause to an economically important tree species. One method of predicting the extent of the potential destruction involves looking at what effect a previous outbreak of the pest species had. One method that foresters use to assess this previous damage is to examine annual tree ring growth before, during and after the pest outbreak. Dendrochronology is a dating technique in which tree rings are measured - sized and counted.

Scientists take tree cores with an increment borer and then use a dendrochonotograph, a specialized stereoscope, to measure the width of tree rings. They can then compare tree growth over many years and look at the effects on tree growth of pest outbreaks, low rainfall, high temperature, and combinations of these and other conditions.

In this activity students attempt to correlate tree growth with major meteorological events, i.e., rainfall and temperature patterns. (There are, of course, many other factors such as competition and pest outbreaks which are not considered here for simplicity's sake.) The resource person could discuss these factors, though, if they are familiar with this type of research.

Meteorological data have been collected for many years. As climatic changes occur, it is important to be able to predict biological changes also. Many methods for "dating" such historical changes are used today. In addition to dendrochronology there are radiocarbon dating, geochronology or varve dating, tephrachronology, and pollen analysis.

Radiocarbon dating is a technique used for determining when organic material was last alive. All living things maintain a constant level of C^{14} (an isotype of carbon), which is in the same proportion as C^{14} is to C^{12} in the atmosphere. When things die, they do not absorb any more C^{14}. Although C^{14} decays extremely slowly, the rate of decay is known and it is measurable. Thus, it is possible to tell when a particular animal became extinct, and research scientists can look more closely at this time period to ascertain the reasons for extinction.

Geochronology or varve dating is used in Scandanavia where there are annual cycles of sediment layer deposition. In spring when ice melts, rivers bring coarse debris down from the mountains and deposit it in the lakes; and in summer when rivers slow, they bring finer soils and gravels for deposition. This annual pattern of coarse and fine sedimentation can be observed and counted.

Tephrachronology is the technique of dating by using ash layers (tephra) from volcanic eruptions. These layers are similar to varves but are not annual.

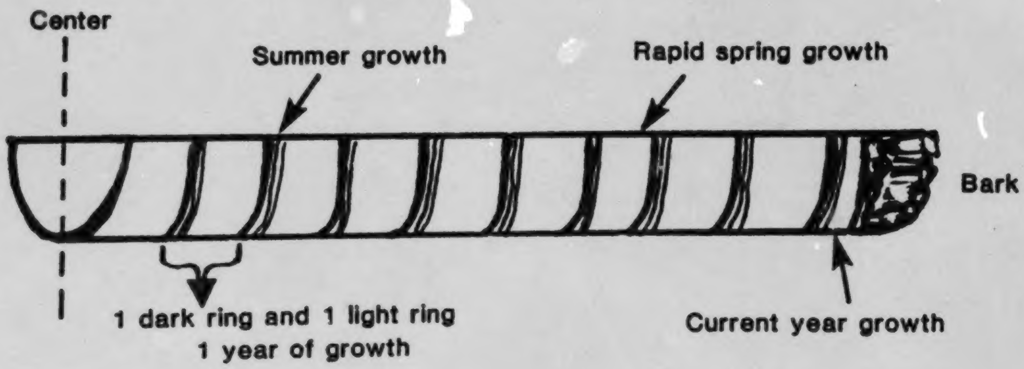
Pollen is remarkably resistant to decay, being able to survive thousands of years and still be identifiable. Thus, paleobotanists are able to study ancient plants. Pollen analyses allow us to get pictures of vegetation at specific time periods as well as profiles of the changing character of the land. We now have an idea of how woodlands developed at different intervals during the Ice Age, how pasture and arable land came into use at particular time periods, and when humans cleared the forests and planted cereals.

Dendrochronology has been used to age bristlecone pines (5,000 years old) and to determine when Calvaria trees last reseeded. Calvaria was found to have last reseeded at about the time the Dodo bird was driven to extinction. One scientist concluded the Dodo must have eaten the Calvaria seeds which then opened up after passing through the Dodo's digestive tract. Even though the

Dodo's gone forever, Calvaria trees will survive. The same scientist is now successfully propagating this tree species by feeding its seeds to turkeys.

Procedure:

Obtain coring instructions from the agency or person who loans you the increment borer, if you, rather than the resource person, plan to take the core samples. Increment borers are easy to use. Borers consist of two pieces, a corkscrew type case and an inner core. The case is screwed into a tree (aim for the middle of the tree; this is as far as you need to go). Next, the corer is inserted and twisted, and then the whole unit is pulled out. Cores can be mounted in clear plastic if desired.



This activity can be conducted in several different ways. If a brief activity is desired, the resource person can bring and describe tree cores; or the resource person may help students analyze the tree cores that the teacher has obtained. The teacher or the resource person could bring students along to core the trees and discuss the differences in tree rings while in the field. At any rate, the purpose of this activity is to have students relate annual tree growth to weather conditions.

Students should select several cores and first determine the age of the trees by counting the annual rings. Then, they can chart each year's growth by measuring the width of the tree ring for the particular year in question. They can compare tree species to see which trees are faster growing. Faster growing trees have wider annual tree rings than slower growing trees. Students can decide which years were more productive in terms of overall growth for the trees which were sampled.

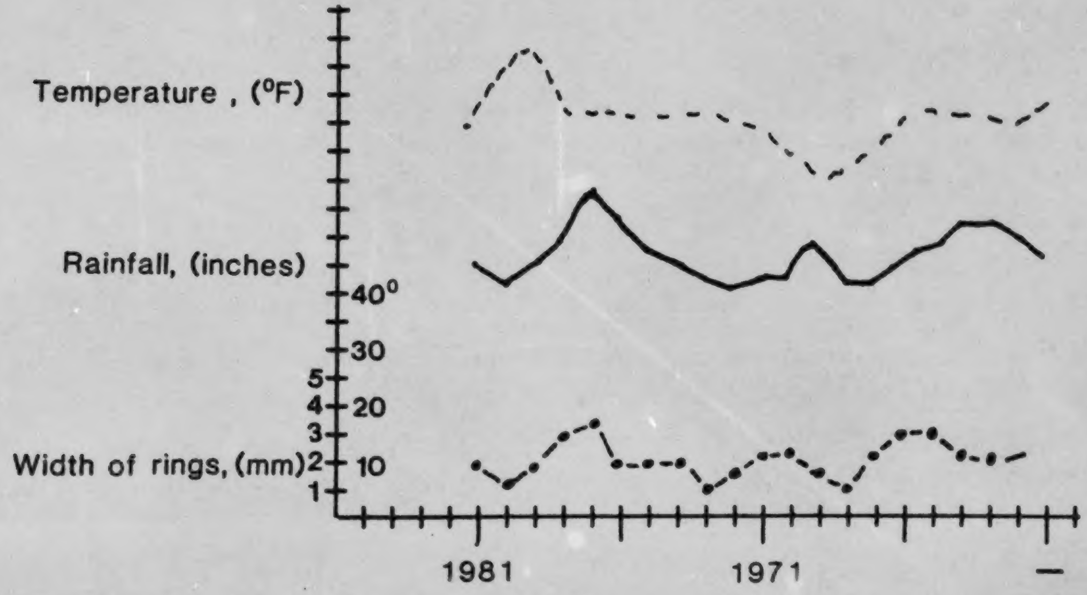
Q

Sample Chart

Year	Width of tree ring
1981	2mm
1980	1.5mm
1979	2mm
1978	3mm
—	—

To conclude this activity, the teacher or resource person can direct the students to make some conclusions regarding tree growth and the general pattern of rainfall and temperature. Students should measure and record the width of annual tree rings for the past 5-20 years and then compare their

Sample Graph



growth rates with temperature and rainfall charts which have been obtained from the National Climatic Center. Students could graph these data as shown on the preceding page. Finally, the teacher or resource person can ask students to discuss the information that could be obtained from coring a particular group of trees. Discuss the relative roles of climate, competition, disease, injury, and overcrowding.

Extension Activity 1:
Changing: Seeing Is Believing

Materials:

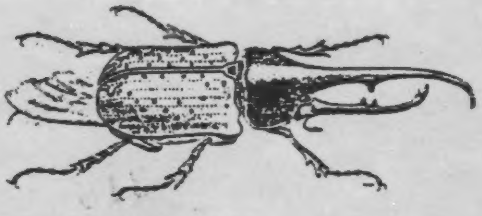
- Larval, nymphal and adult insects - live specimens are preferable but preserved specimens or even pictures will suffice.

Background Information:

Post-embryonic development differs greatly among insects. There are four basic categories of metamorphosis. In ametabolous metamorphosis there is little change in body design between youthful and adult forms (e.g., this occurs in silverfish). In the insects with paurometabolous metamorphosis, as occurs in grasshoppers, there is some change from youthful to adult forms. The dragonfly is an example of an insect with a hemimetabolous type of development. The larval and adult forms are distinctly different, but there are some resemblances. In insects like the tomato horned worm which changes into the sphinx moth, there is no resemblance whatsoever between the youth and adult. They undergo what is called holometabolous metamorphosis.

Procedure:

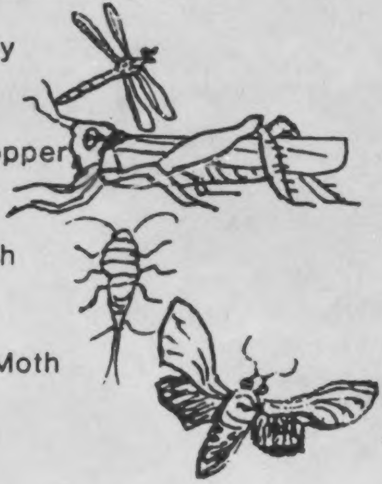
In this activity the teacher can gather live material, preserved forms, or even pictures. This activity would best be done in a learning center situation. Simply lay out the forms on numbered index cards and ask students to pair the youths with the adults. If a resource person chooses to work with this activity, they could bring along some insects with which they work and show the various life stages to your students. This activity can generate interest in other "changes" too. A sample worksheet is included.



Sample Worksheet

Match the adults (on the left) with the proper nymph or larvae (on the right).

1. Dragonfly
2. Grasshopper
3. Silverfish
4. Sphinx Moth



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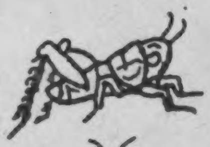

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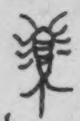

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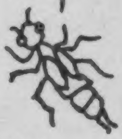

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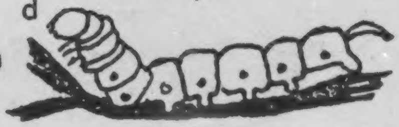


Career Information

Careers in the environmental field are relatively new and environmentalists often have an interdisciplinary background. Most environmental occupations require training in science and mathematics. Chemists, biologists, engineers and geologists can all choose enviromental specialties. Most research positions require an advanced college degree.

Careers in conservation are filled by landscape architects, range managers, hydrologists, environmental lawyers, geophysicists, soil conservationists, agronomists, oceanographers and sanitary engineers. For delightful reading, Ada and Frank Graham's Careers in Conservation features thirteen men and women. Among the thirteen are Maine's first female game warden, a man who studies egrets, a regional Audubon representative, and a lobbyist.

Positions are available with the U.S. Fish and Wildlife Service and other federal, state and local governmental agencies (forestry, parks, geology, water resources, health services, recreation, etc.) Groups such as the National Audubon Society, the Nature Conservancy, and the Wildlife Society also hire environmentalists. A few industries now hire biologists to write Environmental Impact Statements (EIS's) to evaluate the environmental effects of a company's undertakings.

Some careers in the conservation field are occupied by writers (e.g., Carson and Hamerstrom), media specialists, and technicians and aides. Technicians work with scientists and engineers in just about every major occupation in the environmental area. Technicians do not need a college degree, although training at a vocational-technical school, a junior college, or through the armed forces is a definite plus when applying for these positions.

Some conservation positions such as park ranger, interpretive naturalist, and forest ranger are in short supply. They are also relatively low paying. Most people who work in environmental jobs are philosophically committed to "saving our earth" and are willing to accept the low pay and long hours.

A prerequisite to an environmental career is an interest in nature and an enjoyment in working out-of-doors. To see if a conservation career may be for your students, they should begin participating in local clubs which have an environmental slant (e.g., Scouts, 4-H, or Audubon).

Related Activities:

Garigliano, Leonard J. and Knape, Beth Jo (ed.). Environmental Education in the Elementary School. Washington, D.C.: National Science Teachers Association, 1742 Connecticut Avenue, N.W., 20009. 1977. A selection of 52 articles about elementary environmental education from Science and Children, 1971-1976. Focuses on theories about environmental education, and classroom and outdoor activities designed to reinforce environmental awareness.

Hernbrode, William R. (ed.). Multidisciplinary Wildlife Teaching Activities. 1978. Available from Ohio State University, Center for Science and Math Education, 244 Arps Hall, Columbus, Ohio 43210.

About Women and Wildlife:

Facklam, Margery. Wild Animals, Gentle Women. New York: Harcourt Brace Jovanovich. 1978. Describes the experiences of eleven women who study animal behavior. Includes Jane Goodall, Ruth Harkness (giant pandas), Eugenie Clark (sharks), Dian Fossey (gorillas) and Birute Galdikas (orangutans).

LaBastille, Anne. Assignment: Wildlife. New York: E. P. Dutton, 1980. This book highlights the research projects that LaBastille has worked on over the past 15 years throughout Central and South America.

Women and Wilderness. San Francisco: Sierra Club Books, 1980. This book is about 15 women selected from 325 who work in the wilderness.

Recent National Geographic Articles Featuring Women and Wildlife:

Duplaix, Nicole. "Giant Otters: Big Water Dogs in Peril." July 1980.

Fossey, Dian. "The Imperiled Mountain Gorrilla." April 1981.

Galdikas, Birute. "Living With the Great Orange Apes (Indonesia's Orangutans)." June 1980.

Goodall, Jane. "Life and Death at Gombe." May 1979.

Nature Books For Children by Frances Hamerstrom:

Adventures of the Stone Man. Trumansburg, New York: The Crossing Press, 14886.

An Eagle to the Sky. Same publisher.

Walk When the Moon is Full. Same publisher.

For the Teacher by Frances Hamerstrom:

Strictly for the Chickens. Ames, Iowa: The Iowa State University Press. 1980.

With warmth, laughter and understanding the author tells the personal story behind forty years of wildlife research and management in central Wisconsin while trying to save the endangered prairie chicken.

Career Information:

Benson, Christopher. Careers in Conservation. Minneapolis: Lerner Publications Company. 1974.

Describes briefly the careers available in the conservation field including land use planner, ecologist, geologist, meteorologist, sanitation engineer and others.

Berger, Melvin. Jobs That Save Our Environment. New York: Lothrop, Lee and Shepard. 1973.

Introduces the many career positions available in the field of environmental control, including weather forecaster, geophysicist, oceanographer, plant ecologist, sewage plant worker, forest ranger, and city planner.

Graham, Ada and Frank. Careers in Conservation. New York: Sierra Club Books/Charles Scribner's Sons. 1980.

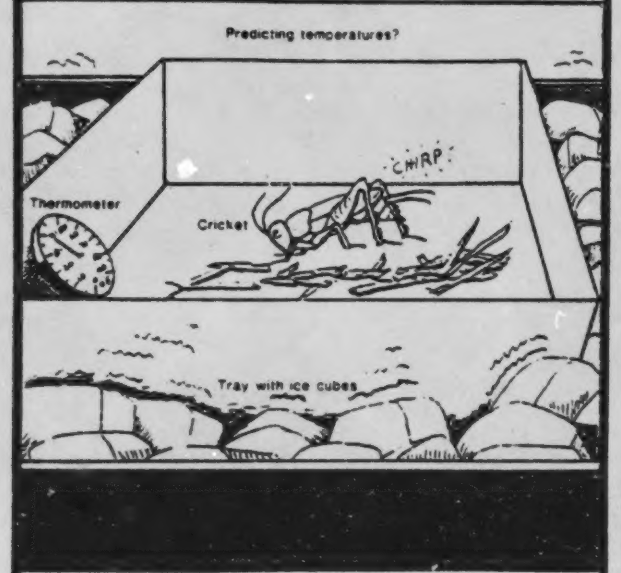
Discusses various career opportunities available to those interested in aspects of conservation including work with plants, endangered species or public opinion.

For More Career Information Write:

The Wildlife Society. 7101 Wisconsin Avenue, N.W., Washington, D.C., 20014. (Enclose 25¢ to obtain a copy of A Wildlife Conservation Career for You.)

The National Wildlife Federation, 1412 Sixteenth Street, N.W., Washington, D.C. 20036. (Ask for the pamphlet, Conservation Career.)

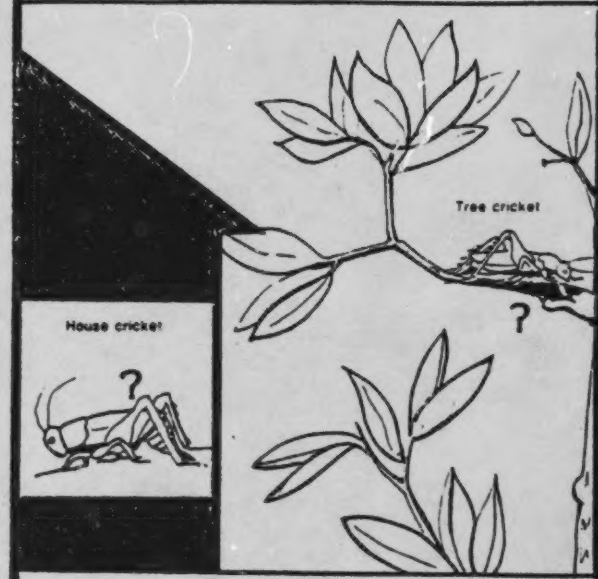
COMETS Challenge Card


Predicting temperatures?
CHIRP
Thermometer
Cricket
Tray with ice cubes

Outdoor People

How low can a house cricket go?

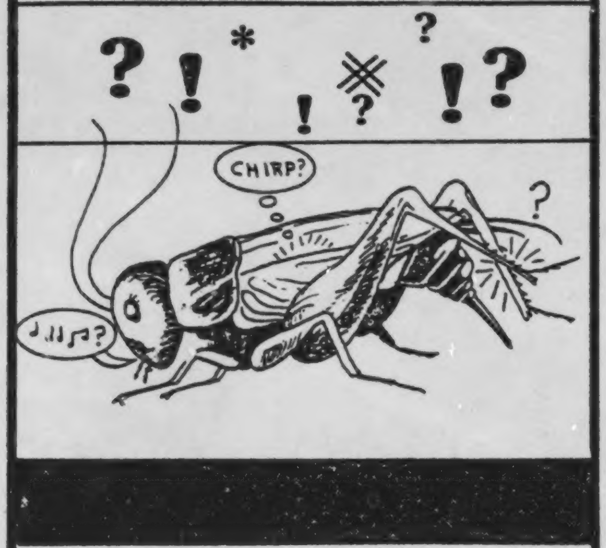
COMETS Challenge Card


Tree cricket
?
House cricket
?

Outdoor People

Which is the most accurate temperature predictor, the house cricket or the tree cricket?

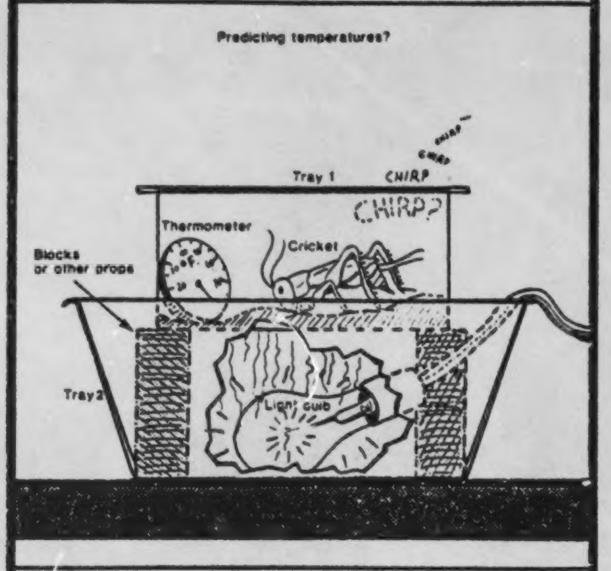
COMETS Challenge Card



Outdoor People

How does a house cricket chirp?

COMETS Challenge Card


Predicting temperatures?
CHIRP
CHIRP
Tray 1
CHIRP
CHIRP?
Thermometer
Cricket
Blocks or other props
Tray2
Light bulb

Outdoor People

How high can a house cricket sigh?

Career Oriented Modules to Explore Topics in Science

Pearly Gates

TOPICS

- Teeth
- Health
- Spatial Skills

RESOURCE PEOPLE

- Dentist
- Dental Hygienists
- Dental Technician

THIS MODULE

Activity I

In "Casting Teeth" students make and examine a mold of their teeth. Dentists, dental hygienists, and dental technicians could serve as resource people. The activity could be completed prior to the resource person's visit and then commented on by the resource person. Simple equipment is used, but care must be exercised. Students can extend the activity by making molds of teeth of people of varying ages.

Activity II

"Tooth Decay" focuses on the action of acid on teeth, emphasizing the role of acid in cavity formation. The work of Patricia Randolph in oral hygiene can be related here (see "Women and Teeth"). Simple equipment is used, but teeth are needed and perhaps could be supplied by the resource person. Several days are required. This activity gives students practice in experimentation.

Activity III

"Seeing's Believing" requires students to use a spatial skill used by dentists who work with a mirror. Students learn to draw an X in a box while looking in a mirror. Simple equipment is required and the activity is brief. In an extension activity, students use additional spatial skills of moving planes in space and correlating the side and top views of objects.

University of Kansas School of Education Department of Curriculum and Instruction

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RELATED MODULES

Pearly Gates is intended for dentists and other dental workers, both people working in the dental office (hygienists and assistants) or in the manufacture of false teeth (dental technician). As health career workers, these resource people could be used with other modules.

Body Detectives

Under the direction of the resource person, students study a body part and equipment with which the resource person works.

Healing Techniques

The X-ray is one technique which students investigate.

Pharmacy

Students learn about drug action and use. The development of nystatin, a drug with oral applications, is described and can be related to the dentist's work.

Fit N' Trim

Genetics is one topic in this module and can be related to this module.

WHERE TO FIND RESOURCE PEOPLE

Local dentists, and dental hygienists and assistants, can be located through the yellow pages. References may be found through a public health agency or local dental society. Faculty and students in dental or predental programs could be invited to class. Ask dentists for referrals to denture manufacturers where dental technicians can be found.

Women and Teeth

Two diseases affecting the teeth, dental caries (cavities) and periodontal disease, are among the most prevalent of human afflictions. Despite the widespread evidence of the salubrious effect of good nutrition and proper personal oral hygiene, dental caries affects 90 percent of the world's population and another 70 percent are affected by periodontal disease. Because these and other malnutrition diseases manifest themselves in the oral cavity and because patients, on the average, are seen more frequently by dentists than by physicians, dentists and dental hygienists are in a particularly good position to spot malnutrition and advise patients on corrective and preventative measures.

Dr. Patricia Randolph has studied these problems and written extensively for both professionals and the public (see, for example, Diet, Nutrition and Dentistry by Randolph and Dennison. St. Louis: C.V. Mosby. 1980). Patricia Randolph's work exemplifies one of science's important functions, the instruction of the general public on research results as these findings affect the daily lives of people. Pat Randolph is "into" teeth.

The causes of cavities are numerous, but clearly the immediate cause of cavities is the action of acid to demineralize teeth. This acid is a by-product of bacteria living in the plaque, a gelatinous material which adheres to the teeth unless removed by proper brushing and flossing. When sugar-containing food is eaten, the bacteria immediately begin to consume it, lowering the pH (acidity) of the plaque to 5.5, a low enough pH to produce demineralization. This lowering of the pH continues for 20 to 30 minutes following the sugar's ingestion.

The detrimental bacterial action is not simply a function of the amount of sugar-containing foods consumed, since the harmful acidic product is active for only 20 to 30 minutes. If sugar intake is limited to mealtime, then the effect of acid can be confined. However, Randolph cautions, if sugar is consumed throughout the day (as in between meal snacks), then the bacterial acid will be present throughout the day.

In addition to good diet (i.e., confining food intake to three meals) and proper brushing and flossing (i.e., keeping the amount of plaque in check and removing the sugar from the teeth immediately after meals), saliva can have a positive effect on preventing tooth decay. First, saliva contains an antibacterial protein, and two, it can buffer (i.e., reduce the acidity of) the acid produced by the bacteria (in much the same way that bicarbonate of soda can be taken to buffer the acid in an upset stomach). Thus, foods which require more chewing and thereby stimulate saliva flow can contribute to cavity reduction. For example, an apple would be preferable to a donut.

The primary mineral component of teeth is hydroxyapatite, $Ca_{10}(PO_4)_6(OH)_2$. If fluoride is consumed during the time when teeth are forming, the fluoride ions take the place of some of the hydroxide (OH) ions, producing a larger crystal with less surface area. Since less surface area is available for acid's effect of dissolving the hydroxyapatite, acid acts more slowly, thus retarding (but not entirely preventing) cavity formation.

This information provided by the writing of dental nutritionist, Patricia Randolph, can be related to Activity II, "Tooth Decay."

R

Activity I: Casting Teeth

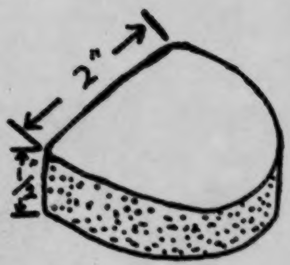
Materials:

- Plasticine or oil base clay (two pieces per student, each about 2" x 2" x ½").
- Strips of heavy paper (about 8" x 1").
- Masking tape.
- Plaster of Paris.
- Container for mixing plaster of Paris.
- Stirrer (e.g., clean stick).
- Water.
- Newspaper.
- Old toothbrush.

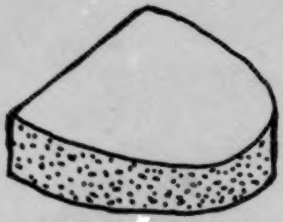
Procedure:

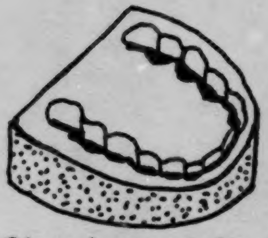
This activity could precede or follow the resource person's visit. Students can do this activity to get a better look at their own teeth, and the resource person can comment on the functions of the teeth. Although the activity takes some time, the resource person's involvement could be brief. Due to possible embarrassment to the individual students, the teeth's condition should be discussed only in generalities. Students with braces should not do this activity.

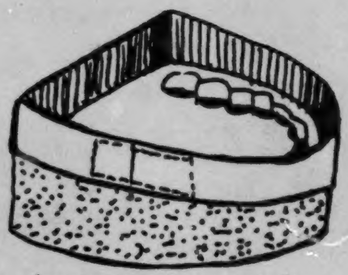
Have students knead the clay until soft and then form it into two slabs that take the shape of their sets of teeth and will fit in their mouths. Have them place the clay slab into their mouth and carefully push it up against the teeth to get an impression of the top teeth. Caution students to be careful



Clay
for top teeth


Clay for bottom
teeth


Clay impression


Impression with
paper dam

R

about not pulling out fillings. (Concerned students should skip this activity.) Have them carefully open their mouths and remove the clay which should contain impressions of their top teeth. If an impression does not come out well, the clay can be kneaded into a new slab and the process repeated. Students should obtain an impression of their bottom teeth in the same way.

Next, students should carefully tape a strip of heavy paper around each slab and fill the mold with plaster of Paris. Dry plaster of Paris should be mixed with water until it becomes a creamy liquid about the consistency of house paint. (If the liquid is too thick, it won't fill the impression evenly; but if it is too runny, it may ooze out of the mold and it will take longer to harden.) Gently tap the mold to ensure that the plaster has settled into all the teeth impressions. Let the mold sit for at least one hour, but waiting overnight may be safer. When the plaster is completely dry, the clay and paper can be carefully removed to reveal a complete set of teeth. Excess bits of plaster or clay can be gently brushed away with an old toothbrush.

Have students look at the general form of their teeth. Which teeth are best for cutting food? . . . best for grinding food? What parts of their diet would require each type of teeth? Have them look for missing, misplaced, and/or decayed teeth. Have them put the two sets of teeth together and check out their fit. Do the grinding and/or cutting teeth fit? How many teeth do they have? Do all students have the same size and number of teeth? Interested students could make similar teeth molds of family members of varying ages, from preschool through adulthood. Then comparisons could be made in shape, size, and numbers of teeth.

Activity II: Tooth Decay

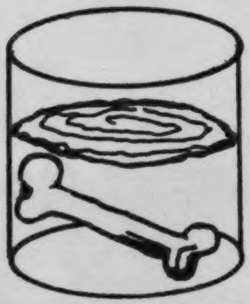
Materials:

- Old teeth, egg shell, and small bones.
- Vinegar.
- Soft drink.
- Water.
- Small jars, drinking glasses, or similar sized jars.

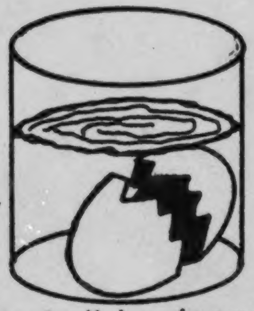
Procedure:

The enamel of teeth is tough but reacts with acid. Acid's action on teeth produces cavities. People do NOT often consume acid; but they do consume foods which bacteria in the mouth use as their food source. One by-product of the bacteria's metabolism is acid, which does decay teeth. This activity is designed to show how acid affects teeth. Since it takes several days, it should be started well ahead of the resource person's visit.

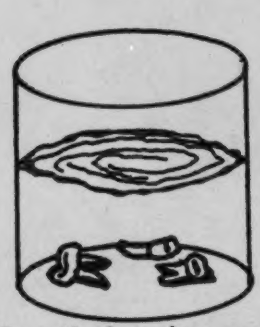
Depending on the amount of available equipment, students should work individually or as a group to perform this experiment with two independent variables, type of liquid (vinegar, soft drink, or water) and type of solid (tooth, shell, or bone). Nine jars are needed, three each for vinegar, soft drink, and water. For each set of three jars, add a tooth to one, shell to a second, and bone to a third. A sample of each solid should be kept for subsequent comparisons. The contents of each jar can then be observed daily for two or three days and then each two to three days. Observations should be recorded on the type of chart shown on page 8.



Bone in vinegar



Eggshell in vinegar



Teeth in vinegar

Type of Liquid	Type of Solid	Observations Day 0	Day 1	Day 2	Day 3	Day 4	Day 5
Vinegar	Tooth						
	Shell						
	Bone						
Soda Pop	Tooth						
	Shell						
	Bone						
Water	Tooth						
	Shell						
	Bone						

- = No change   + = Change

Observations can be discussed as they are collected. Ask what effect the acid (vinegar and soda pop) had on the solids. (Each of these solids is composed of a large amount of carbonates which react with the acids to soften them.) Relate here the work of Patricia Randolph which is so important for good oral hygiene (see "Women and Teeth").

R

Activity III : Seeing's Believing?

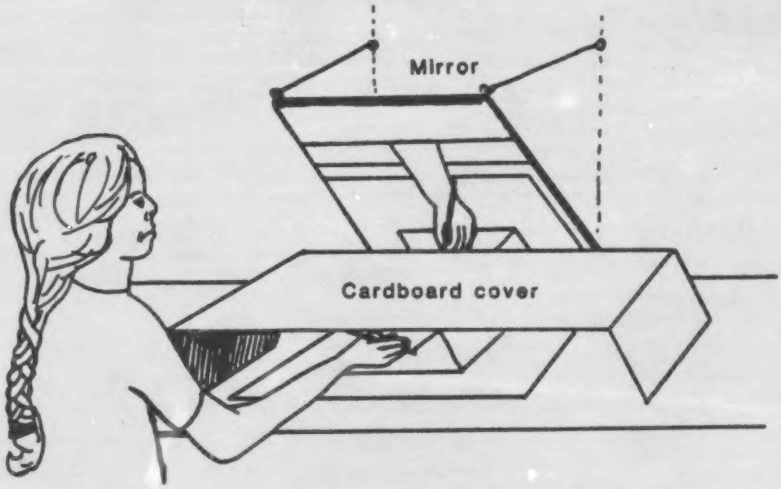
Materials:

- Mirror, pocket size or larger and preferably square or rectangular.
- Paper and pencil.
- Cloth or paper about 12" x 12" or larger.

Procedure:

This activity demonstrates one skill needed by dentists who, while working in the patient's mouth, must be able to use a mirror image to guide their work. This activity is brief and captures student interest as they try to master the skill, so it can be used in its entirety by the resource person.

Have students draw on their paper a box with an X in it. Next, have them cover their hand and paper with cloth or a paper towel and hold the mirror so they can see their drawing only in the mirror. Have them repeat the process of drawing a box with an X in it and practice this skill until they become somewhat proficient. Finally, have them remove the cover from over their hand and the mirror and again draw the box and X.



Students will have difficulty at first drawing the box and X while looking in the mirror, but they can learn to be more proficient. Surprisingly, many students will notice a moment's awkwardness in drawing the box and X when the mirror and cover are removed. They find that they had to readjust their coordination of their visual observations with their drawing. Resource people can then comment on how they have to use a similar skill in their work.

Extension Activity 1: More Spatial Skills

Materials:

- Challenge Cards, one set for each student.

Procedure:

Dentists need to be able to perceive and work with three dimensional objects. For example, they need to shape a filling so it will fit together with the surface of the opposing tooth. The Challenge Cards can be used only to illustrate this skill and not to provide instruction to improve the skill. This activity could be used by the resource person following Activity III or it could be done by the teacher subsequent to the resource person's visit. Distribute the cards separately or together. If students have difficulty, they can cut out paper and make the shapes.

Boxes B, C, and E can be made in the first Challenge Card. B is the box turned so the small rectangle is unseen in the back. E is the box turned over with the triangle underneath.

Cones A and C can be made in the second Challenge Card.

In matching the side and top views in the final Challenge Card, one goes with C, two with A, three with D, and four with B.

Career Information

Four different dental careers are practiced There are 120,000 dentists, 35,000 dental hygienists, 150,000 dental assistants, and 47,000 dental technicians. The first three jobs are primarily pursued in a private dental office or clinic, and the technician's work is usually done in a separate laboratory.

The dentist, who usually has four years of undergraduate schooling, four years of professional dental training, and perhaps one or more years of additional postgraduate training in dental specialties, examines and treats patients for oral diseases and abnormalities. The dental hygienist, who usually has two to four years of training after high school, cleans teeth, makes X-rays and advises patients on proper oral hygiene. Both the dentist and the dental hygienist must meet state license requirements prior to practice.

A dental assistant, who is usually trained on the job, aids the dentist by handling tools, maintaining records, acting as receptionist, and doing other office tasks. Most dental assistants have completed high school, but no additional formal training is required.

R

The dental technician also receives most training on the job, but training is available in the armed forces and in some vocational schools. This person transforms the dentist's written prescription and impressions of teeth to produce dentures, crowns, and other oral apparatus.

Career Information:

Where I Want To Be: The Story of a Woman Dentist. Movie available for rent ($10.00) from American Dental Association, Bureau of Health Education and Audiovisual Services, 211 E. Chicago Ave., Chicago, Illinois 60611. 1973.

COMETS Profiles:

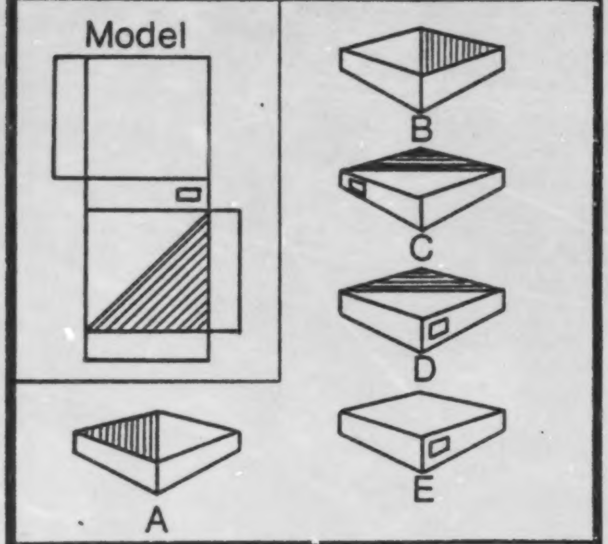
Mary Jo Frazier: Dentist.
After starting college as a music major, Jo Frazier turned to dentistry and now combines private practice with research.

For More Career Information Write:

American Dental Association, 211 East Chicago Avenue, Chicago, Illinois 60611.

Division of Professional Development, American Dental Hygienist Association, Suite 3400, 444 N. Michigan Avenue, Chicago, Illinois 60611.

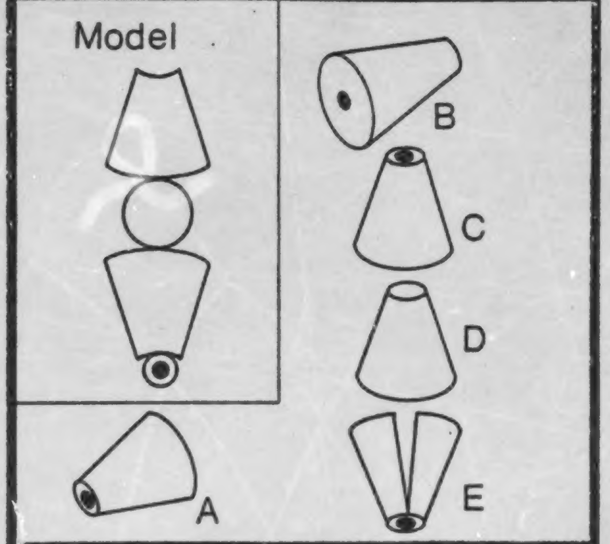
COMETS Challenge Card


Model
B
C
D
E
A

Pearly Gates

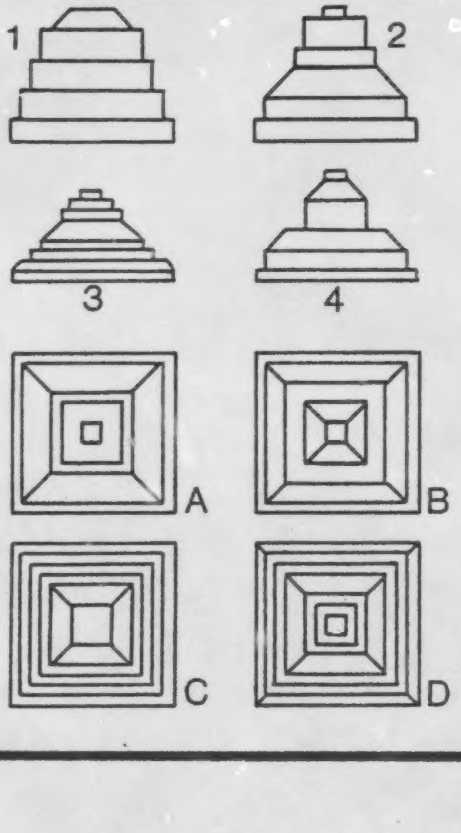
Which box or boxes show how the model would look after it was folded?

COMETS Challenge Card


Model
B
C
D
A
E

Pearly Gates

Which cone or cones show how the model would look after it was folded?

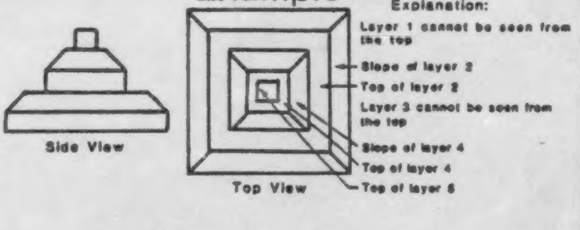


COMETS Challenge Card

Figures 1, 2, 3, and 4 are side views of figures A, B, C, and D (top views). Match Figures 1–4 (side views) with their respective top views (A–D). See the example before starting.

Pearly Gates

Example:


Side View
Top View
Explanation:
Layer 1 cannot be seen from the top
Slope of layer 2
Top of layer 2
Layer 3 cannot be seen from the top
Slope of layer 4
Top of layer 4
Top of layer 5

Career Oriented Modules to Explore Topics in Science

TOPICS

- Sociology
- Psychology
- Anthropology

PEOPLE WATCHERS

RESOURCE PEOPLE

- Sociologist
- Psychologist
- Anthropologist

THIS MODULE

Activity I

In "Sociograms" pupils use quantitative (sociometric) methods to analyze social relationships within a hypothetical seventh grade classroom. Given a data sheet on which has been recorded the responses of 14 seventh graders who were asked, "With which two class members would you most like to work on a class project?," students construct a sociogram which helps them analyze the informal structure of this particular seventh grade. This activity could be directed by the resource person (a sociologist, psychologist, anthropologist or human geographer would be a good choice) or the resource person could comment on the conclusions drawn, if students completed this activity before the visit. The work of cultural anthropologist, Dr. Margaret Mead, can be recounted here.

Activity II

"Amazing" requires simple equipment but at least a class period or two for completion. Students construct finger mazes with yarn, straight pins, and cardboard and then run time trials with their blindfolded classmates. The extension activity, "Number Mazes," is very simple, requires only pencil and paper, and a watch or clock, and well illustrates the facets of learning with which many psychologists are concerned. Ethologists (animal behaviorists) also investigate learning. They are more concerned with non-human animals though. (For information on ethologists, see Outdoor People.)

Activity III

"Garbageology" or ashcan archeology has students sifting through garbage to find out what they can about the people who left these trappings. Collection and assemblage of garbage is the only advance preparation necessary for this activity. The work of Dr. Margaret Mead and Dr. Anne Buttimer can be related here.

University of Kansas School of Education Department of Curriculum and Instruction

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RELATED MODULES

Social scientists - anthropologists, archeologists, sociologists, psychologists, lawyers, geographers, economists - are the targeted scientists for this module, People Watchers. Other modules have activities which could also be used by a visiting social scientist. These modules include the following.

Bones and Balance

Mildred Trotter is an anatomist who has made many contributions to physical anthropology. Her work is presented in this module in relation to Activity II, "Classification."

Third Dimension

Archeologist, Dr. Mary Leakey, is featured in "3D Structures" and "2D Tangrams." Her African discoveries have added immensely to our understanding of our ancestors and their cultures.

Find Some Evidence

The activities in this module give students some idea of physical evidence on which lawyers base a criminal case. Sociologists and psychologists could extend these activities on physical evidences to include circumstantial evidence.

Outdoor People

Ethology (animal behavior) is considered by some to be a social science. Ethologists investigate learning in non-human animals. Activity II, "Tracking, Trekking," features well-known primate behaviorists Jane Goodall, Birute Galdikas and Dian Fossey.

WHERE TO FIND RESOURCE PEOPLE

Psychologists are the most visible of the social scientists. They work in colleges, universities, schools, businesses, corporations and advertising agencies, and some are privately employed. See the yellow pages. Your public school system probably has an educational psychologist who could address the topics in this module. Some museums employ archeologists or anthropologists.

In addition to the professionals, many lay people have also had an opportunity to participate in the social sciences. Perhaps you can find someone who has participated in an archeological dig. Many cities have archeology clubs which are often associated with state or local historical societies. A librarian may refer you to people interested in archeology or the history of the area.

Women in the Social Sciences

The New Women in Social Science according to Kathleen Bowman (see bibliography) are Cynthia Cone (anthropologist), Alice Rubin (economist), Margaret Mead (anthropologist), Barbara Tuchman (historian), Sylvia Porter (economist), Jane Goodall (ethologist) and Joyce Brothers (psychologist). All are women who have made outstanding contributions in their fields of endeavor.

However, only Margaret Mead, our foremost anthropologist, is featured in this module. Margaret Mead, who died in 1978, was interested in "studying the lives of other people. . . so that Americans might better understand themselves." In addition to her work in anthropology she was a lecturer, columnist, writer and critic of modern America. She was concerned with juvenile delinquency, family planning, world peace, drug addiction, careers for women, and the population explosion.

Margaret Mead was one of the first persons to go to primitive cultures and bring back eyewitness reports. Her direct involvement with other cultures resulted in major modifications to what were once-accepted conclusions regarding primitive life. Her first book, *Coming of Age in Samoa*, was published in 1928 when she was 27 years old. It was a scientific, anthropological study of adolescence in a small primitive village of island people. It was and still is a classic. Mead's many other visits with many other peoples shed much light on the long-range goal of cultural anthropology - to better understand human nature.

As an anthropologist, Margaret Mead studied tribes of people to try to find out what things were similar in various cultures and what things were different. Her inquiries revolved around questions such as the following examples. How does this tribe provide food, shelter, and clothing? How are families organized? How are rules made? What language do the people speak? Mead studied their art, beliefs, and customs. When Mead went to live in Samoa, she learned the Samoan language, ate raw fish, and slept on pebble floors. She fished with the village women and helped them cook and weave. On Samoa, Mead discovered that adolescence was not painful for girls there as it often is here in the U.S. Thus, she argued that it was not "natural" for teenagers to be sulky, highstrung, and rebellious; these traits are part of the culture.

Mead is not the only notable woman anthropologist. Both Mildred Trotter (Bones and Balance) and Mary Leakey (Third Dimension) are featured in other COMETS modules. There are, of course, many more women who have been and are eminent contributors to the social sciences.

Women psychologists, psychoanalysts, anthropologists, educators and lay people have all been credited with making eminent contributions to psychology. Leta Hollingworth (1886-1939), a clinical psychologist, did the pioneering work on the psychology of women at a time when psychology was being used to justify women's disadvantaged status. With empirical research on women's mental and physical performances during their menstrual cycle, on the variability hypothesis (which proposed that men's higher status was due to greater male variability), and on women's sex roles, Hollingworth refuted a number of myths that supported the idea that women were inferior to men. During her lifetime Hollingworth served as psychological advisor to between 4,000 and 5,000 distressed individuals. Many of her books are still standard required texts for college psychology classes on the subnormal as well as the gifted child. Her work on women provided a scientific pillar for the women's movement.

Human geographer, Dr. Anne Buttimer, believes that our values affect the way that we organize space and use our environment. Human geography is the study of the land or region where people live and how this location on the globe determines the kind of life that they lead--their standard of living, and their development. Human geographers study climate, topography, and mineral wealth, in relationship to a people's universities, government services, and economics, for example. Dr. Buttimer has worked in areas where reconstruction has been extensive. She feels that many redevelopment projects result in housing which is better suited to serve the interests of the suppliers of services rather than those who are to live there. Because these housing projects are developed to be spatially efficient, they often do not meet the needs of their dwellers and even cause a change in value systems of the inhabitants. Dr. Buttimer's work can be mentioned as students participate in Activity III, "Garbageology."

Activity I: Sociograms

Materials:

- One copy each of the "Sociogram Data Sheet" and "Sociogram Interpretation Sheet," pages 8 and 9.

Background Information:

Sociology is the study of the evolution of society, the forms and functions of groups of people. Among other things, sociologists study farm and city communities, population figures, occupations, age levels, conditions that produce criminals, problems of minority groups, and gerontology (problems of old people).

Some sociologists use quantitative methods called sociometric methods to help them analyze social relationships within and between groups and to help them determine the informal, underlying structure of a group. In this activity, students construct a sociogram which enables them to analyze how members of a group judge and respond to each other.

Sociograms are useful tools for visualizing relationships. Sociograms generally consist of a schematic representation of group members with lines depicting channels and directions of influence. Double headed arrows on a line usually depict mutual choice between two group members while single headed arrows represent a dependent rather than interdependent choice. Solid lines can depict primary choices; dotted lines secondary choices. Once a 'map' of the group's process of interaction is constructed, it is possible to identify:

1) the stars, those who are most frequently selected as first choice by others,

2) the social isolates, those who are not selected by others, and

3) dyadic or triadic clusters within the group, indicating consistent intimate friendship patterns within the larger group.

The sociogram is a limited tool, though, as it indicates only a general pattern of interaction for specific situations and tells nothing about the subtle nature and form of daily interaction within the classroom. Participant observation by the researcher in the daily life of the group over an extended period of time can lead to identification of the consistently important social roles and their relationships. This is the type of investigations that Margaret Mead conducted. Participant observation is time consuming and costly.

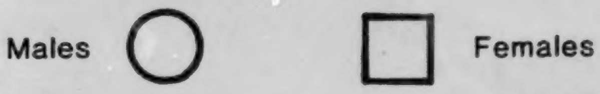
It runs the risk of bias and impressionistic interpretations. Nevertheless, it can be productive, as Mead has decidedly proven.

Procedure:

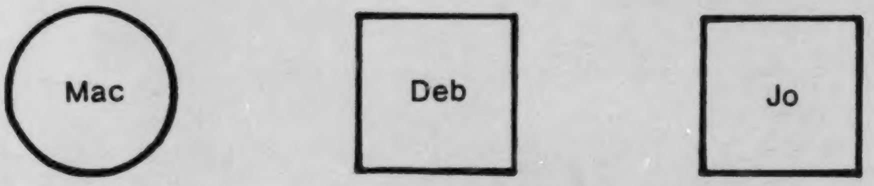
Reproduce the Sociogram Data Sheet and the Sociogram Interpretation Sheet for each student. If your resource person is conducting this activity, they could start by talking briefly about how they use sociometric methods in their work.

The Sociogram handouts could then be passed out while the resource person explains the questions that students were asked and the answers as tabulated. For example, the resource person could say, "A sociologist asked Deb which two of her classmates she would most prefer to work with on a class project." Deb replied, "Mac and Jo." After doing a few more of these examples on the board (e.g., "asked Jo with whom she would most like to work"), the resource person or teacher could then explain how to represent the data in graphical form, i.e., how to make a sociogram.

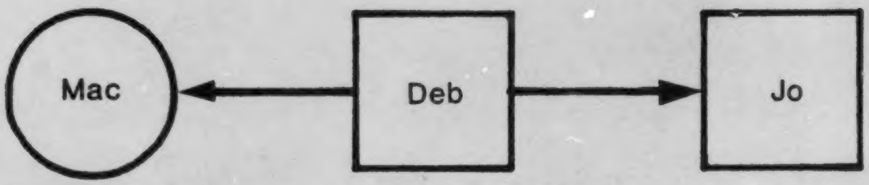
Have students draw circles for males and squares for females.



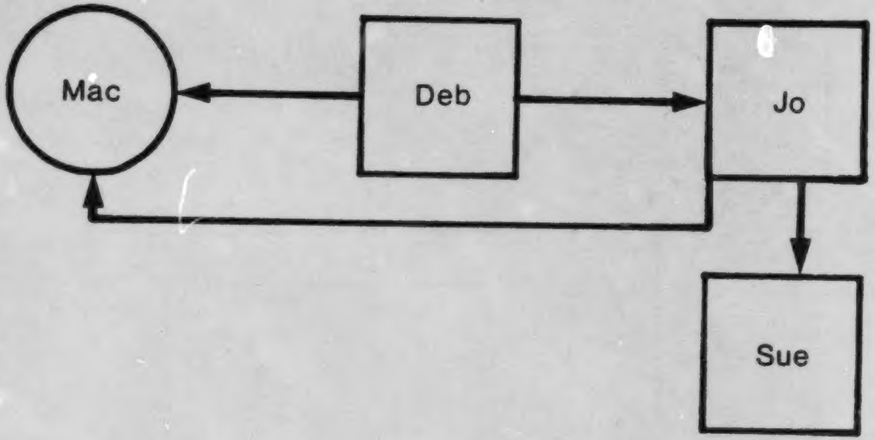
Put the names of the students in these shapes.



Then draw arrows from Deb's square to show with whom she has chosen to work.



Next, look at Jo to see which two classmates she has chosen. Add their squares and names. Continue doing all of the females and then start another pattern with the males.



After completing these two sociograms on scratch paper, students can transfer the data to their Sociogram Interpretation Sheet. Before doing that though, have students answer the questions on that sheet. The resource person should direct this session and define terms such as "isolate" and "star" on the Sociogram Interpretation Sheet. After the questions have been answered, instruct students to fill in and depict accurately and graphically the classroom structure for boys and girls in this seventh grade. For example, the stars should be in the center, the clusters grouped together and the social isolates separate from the group.

The choice of a class member should be represented by a solid-line arrow. Indicate a mutual choice by a two-headed arrow and a one-way choice by a one-headed arrow, with the direction of the arrow indicating the person chosen. In each circle or square, write the name of the person and the number of times the individual was chosen.

Sociogram Data Sheet

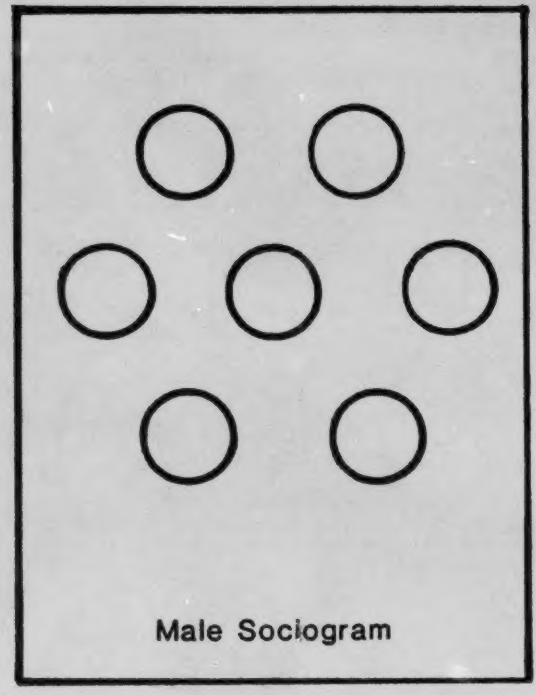
Fourteen individuals in a seventh grade classroom were asked to respond to the question, "With which two class members would you most like to work on a class project?" On a piece of paper the individuals placed their own name and the names of two class members. (They were not asked to list the class members in order of preference.) The compilation of those data is shown here.

MALES	CHOICES	
Dick	Cy	Mac
Ed	Mac	Lou
Mac	Cy	Al
Lou	Ed	Mac
Cy	Dick	Mac
Les	Mac	Dick
Al	Lou	Ed

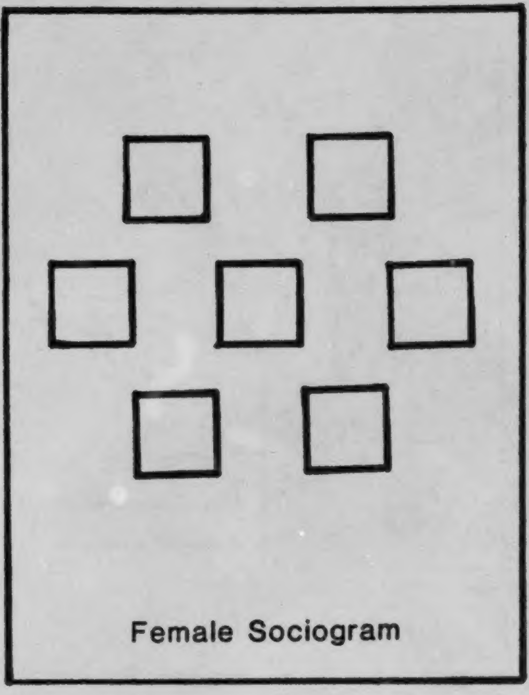
FEMALES	CHOICES	
Ann	Nina	Mary
Jo	Sue	Mac
Sue	Babs	Mary
Deb	Mac	Jo
Mary	Sue	Deb
Babs	Deb	Sue
Nina	Jo	Deb

Using the data given, construct a sociogram for both males and females, with circles for males and squares for females. Draw the first sociogram on scratch paper, as the first attempt may not represent the best organization for the placement of names. Place the final sociogram on the Sociogram Interpretation Sheet.

Sociogram Interpretation Sheet



Male Sociogram



Female Sociogram

Which member(s) was a "star" (chosen most) in the males? ____________

Which female(s) was a "star"? ____________

Which male(s) was an "isolate" (chosen least)? ____________

Which female(s) was an "isolate"? ____________

Which person(s) might be used as "contacts" between females and males?

____

Assume you wanted to form three groups, distributing stars, isolates, and contacts as even as possible among the groups. (This is one technique a teacher or other group leader can use to enhance communications among members of a larger group.)

Group 1 ____________

Group 2 ____________

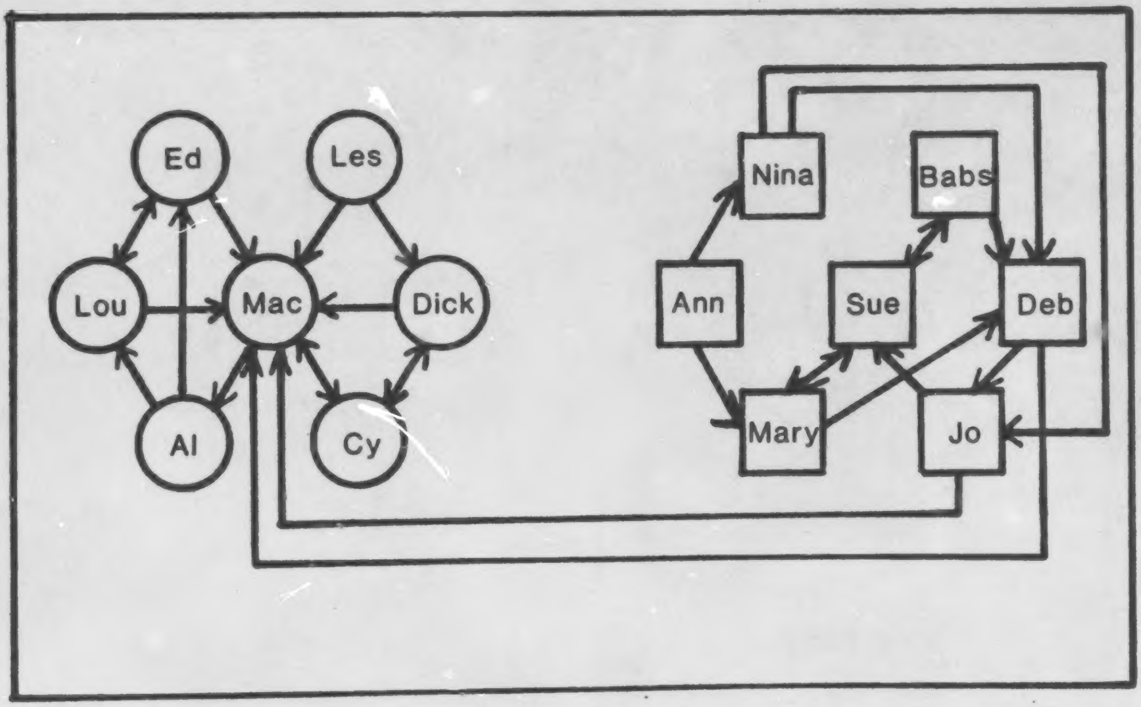
Group 3 ____________

If the question had been, "What two class members would you be sure to invite to a party?," do you think you would have received the same answers? ______

Why? ____________

S

Sociogram Interpretation Sheet - Answers



Mac is a male star (chosen by seven classmates).

Deb and Sue are female stars (chosen by three each).

Les and Ann are isolates.

Mac, Jo, and Deb are potential contact people between the females and males, since Mac was chosen by Jo and Deb.

Various groupings are possible; but if stars and isolates are to be spread, then Mac, Deb, and Sue (stars) and Ann and Les (isolates) should go into different groups. Mac, Deb, and Jo, as potential contacts, should be spread.

If a different question were asked, you might expect different groupings because of the difference in personal characteristics involved. However, because of a halo effect (stars are stars, regardless of the task), fewer differences might be expected.

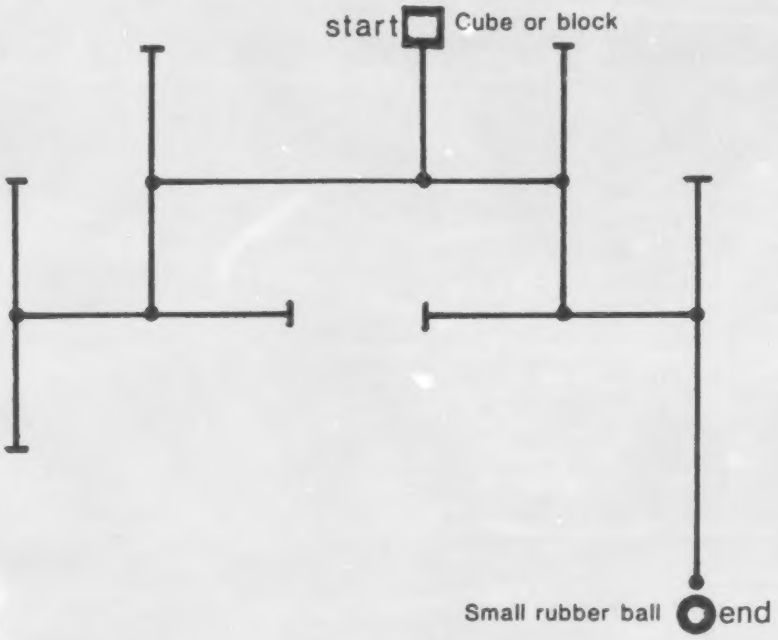
Activity II: Amazing

Materials:

- Stiff cardboard.
- Masking tape.
- Cardboard boxes.
- Yarn.
- Straight pins.
- Watch or clock, with second hand.
- Bandanas for blindfolds.
- Something to denote start and end--styrofoam balls, cubes, small flags, etc.

Procedure:

Have students construct mazes similar to, but not exactly like the one below, by first drawing a pencil pattern on their cardboard. There should be no more than five decision points (points where a left or right turn is required) between the start and end. Then stick straight pins into the cardboard at regular intervals on straight lines and at all turns. Finally, connect a length of yarn to the straight pins by circling each pin head several times to form a finger maze.

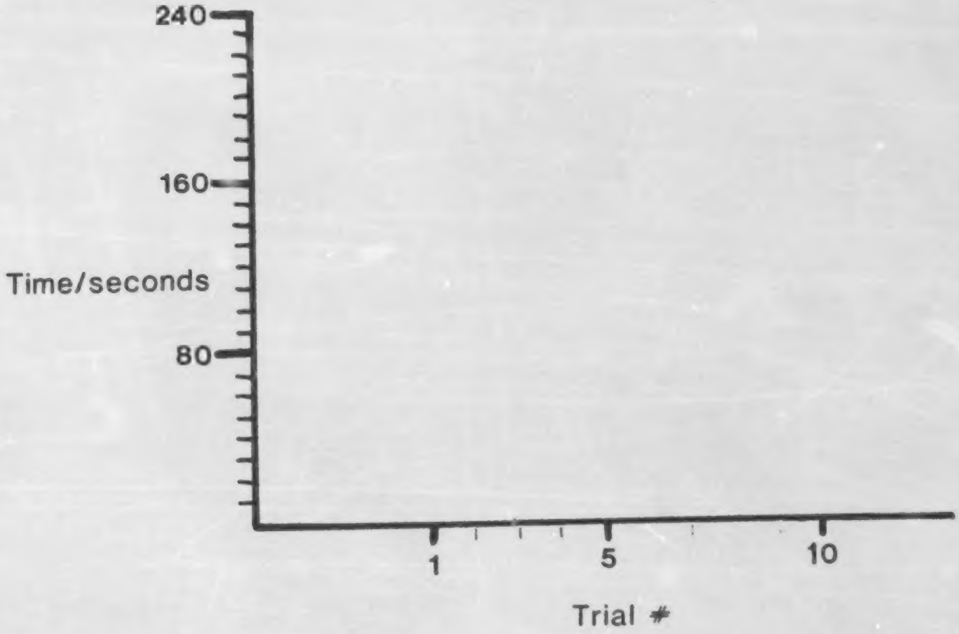


S

Pair students so that one is blindfolded and the other selects a maze. Have this student record the time that it takes the blindfolded student, using only the left or right forefinger, to complete the maze on ten different trials.

Trial	Time (Seconds)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Then exchange the blindfold and have the partner select a different maze. Again record the times for ten trials. When both students have completed ten trials, graph the data as shown below.



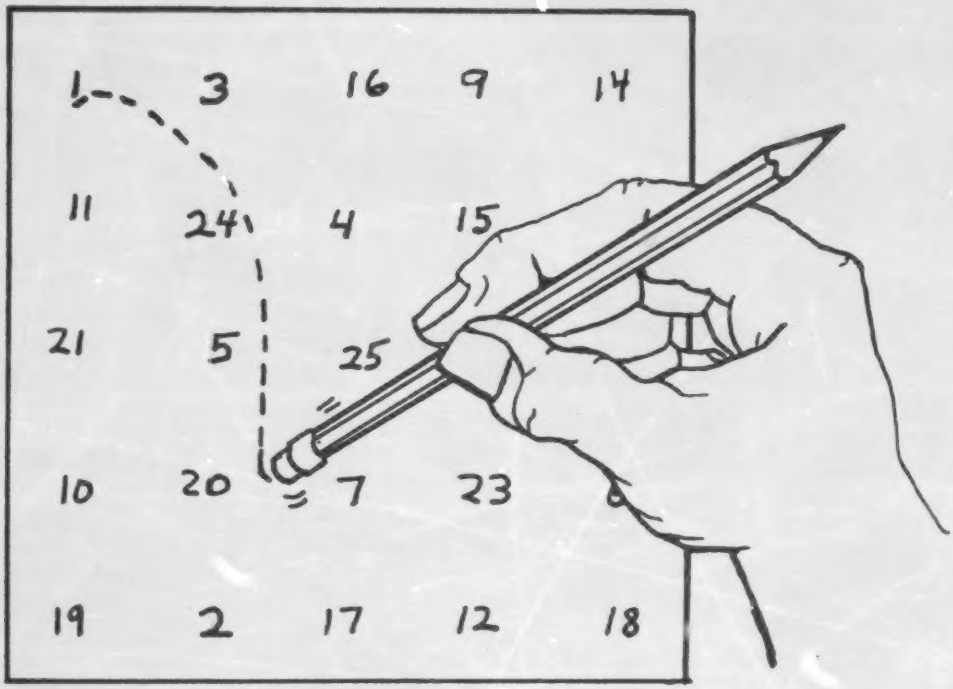
Extension Activity: Number Mazes

Materials:

- Paper.
- Watch or clock.
- Pencil.

Procedure:

Construct a number maze by writing the numbers from 1 to 25 in random order on a sheet of white paper. Have subjects point to the appropriate numbers (1 to 25 in sequence) with the eraser end of their pencils. Record the time for a number of trials until the time does not decrease much for several successive trials. Record and graph data as before.



Another extension activity could involve running random 25-number mazes under different conditions. For example, students could conduct the activity as described above under fairly relaxed conditions. Students could then perform the same activity using different mazes under conditions which are distracting (e.g., loud music). Students could try a third maze but have a

S

half hour interruption midway through the time trials. Discuss the various conditions of learning and the outcomes with your students.

Learning is one of the most important aspects of behavior that psychologists study. Psychology is the study of why people are the way they are and why they do the things they do. Psychologists are interested in how peoples' minds work. Educational psychologists study the ways in which people learn so that they can determine various ways that teachers can be more effective. Your students can try to generalize what they found out about learning under conditions of relaxation, distraction, and interruption. The work of educational psychologist Leta Hollingworth can be mentioned here.

Activity III: Garbageology

Materials:

- Bags of "stuff" (one bag for every three to five students.) "Stuff" can come from any trash heap, but a visit to the city landfill is certain to prove fruitful. A suggested list of ten items for five bags of "stuff" follows:

Bag 1
football program
empty pop bottle
old tennis shoe
hot dog wrapper
pop record - broken piece
flea collar
ping pong ball
orange peel
old campaign button
bobby pin

Bag 2
ticket stub - opera
caviar can - empty
Neiman Marcus catalog
worship program from church or synagogue
bill from lawn care company
eye shadow container
empty box of dishwashing detergent
reed to a musical instrument
35 mm slide
ink pen

Bag 3
chopsticks
chicken bone
battery
newspaper
cereal box
paper clip
stamp
playing card
clothespin
match

Bag 4
bubble gum wrapper
pacifier
car key
paper diaper
dime
page from telephone book
old tire
jar
light bulb
piece of water hose

Bag 5
ticket stub - rock concert
broken plastic comb - large
psychodelic shirt - old
roller skate key
Stevie Wonder record
empty pop can
broken painting
envelope
towel
piece of wire

S

Background Information:

Begin this discussion by pointing out the differences between anthropology and archeology. Anthropology is the study of the development of a people and their civilizations while archeology is the study of things made and used by people. Anthropologists ask such questions as "How did this race begin?" or "Which people first settled in this part of the world and why?" Cultural anthropologists like Margaret Mead study the ways that people in a particular culture look, live and behave; they usually study living cultures rather than past civilizations. Physical anthropologists like Mildred Trotter (see Bones and Balances) study teeth, bones and tissues of people to gain clues about civilizations. Mary Leakey (see Third Dimension) discovered evidence of a forerunner of Homo sapiens.

Archeologists spend much of their time digging, dating and analyzing finds. Archeologists study the material remains as a means of reconstructing the stories of past peoples on the earth. Material remains, called artifacts, are simply all objects used by people in their everyday lives--tools, toys, furniture, decorations, gadgets, weapons and even buildings that have been lived in and worked in.

Recently, anthropologists have excavated turn-of-the-century coal mining towns, examined the remnants of traditional cowboy values from the 1920's, and excavated urban land dumps filled as recently as the 1950's. Now, anthropologists are even busy studying last night's refuse to learn about today's culture. "Ash can archeologists" are busy digging through neighborhood trash in places like Milwaukee, Los Angeles, Tucson, Mexico City, and Sydney, Australia. They have found that:

- 15% of Tucson, Arizona's edible food is wasted at an annual cost of $11-13 million.
- when the cost of items like beef rises, more of it suddenly shows up in garbage.
- premium brands are a middle-class phenomena; the wealthy economize by purchasing house or generic brands.
- in the same garbage bag there are wrappers from both "junk food" and natural, no preservative food. (Researchers have dubbed this "garbage schizophrenia.")
- alcohol consumption is about eight times greater than what residents claim.

Garbageology is defended by archeologists who maintain that our ruins are much more impermanent than those of earlier times due to our practice of ripping out buildings down to their foundations and carting off the rubble to be bulldozed, mixed up and crushed. If we are to preserve anything, we have to start digging sooner.

Procedure:

Assemble bags of stuff before beginning this activity. You could prepare one bag of stuff and have groups of students complete this activity at a learning center; or if you assemble five bags (for 2-5 students), the entire class could complete the activity at the same time. If your resource person is directing this activity, all students should either conduct the activity at the same time or should have completed the activity before the resource person's visit. Give each group of students (2-5 people per group) a bag of stuff. Have them make a list of the items in their bag.

Make up a list of questions to put on the blackboard to help students in their analyses. Include questions such as:

1. What was the diet of these people? Were their foods homegrown or imported? (Look through food scraps; read labels on bottles, cans and other packaging for ideas.)
2. What kind of fuel did these people use for cooking and heating? (Look for bills; read directions.)
3. In what kind of community did these people live? (Look at newspapers.)
4. What kinds of games did these people play? What other forms of entertainment did they pursue?
5. What sort of money system did these people use? Can you figure out how it worked?
6. What was the family structure like? How were families organized?
7. Were the people educated? Could they read?

If students complete this activity during the resource person's visit, that person could circulate from group to group pointing out different ideas that the group may not have considered. This is an excellent time to mention the work of Dr. Margaret Mead and the investigations of Dr. Anne Buttimer.

Career Information

Social scientists are persons who study humans as living and historical beings. Social science is a fairly new discipline, having come into existence in the past 100 years or so. In that time the field has branched out into many specialized areas. Psychologists, sociologists, economists, historians, lawyers, anthropologists, archeologists and geographers are all social scientists.

All of these professions require a college degree and a graduate degree is necessary to advance very far in most fields. A law degree and a passing score on the bar exam are necessary to practice law. Most clinical psychologists have a Ph.D.

Social scientists work in hospitals, in health departments, and in laboratories. They work for the government, acting as advisors on technical assistance, on educational programs for people coming into the modern world, and/or panels that deal with relations with other countries.

There are many more women in the social sciences than there are in the natural sciences. One out of every four psychologists is a woman. As time goes on, this percentage will increase, for more women than men are enrolled in doctoral programs in psychology.

Just as there are a wide variety of professional positions, so there are also a wide variety of paraprofessional positions. Mental health assistants have at least an associate degree, although most have a bachelor's degree.

Related Science Activities:

Anthropology Curriculum Study Project. Teacher Service Materials, published by the American Anthropological Association (address below).

Gould, Laurence J. and Martin, William G. Think About It: Experiments in Psychology. Englewood Cliffs, N.J.: Prentice-Hall. 1968.

"Images of People." Sociological Resources for Social Studies. Episodes in Social Inquiry Series. Boston: Allyn and Bacon. 1969.

Porell, Bruce. Digging the Past: Archeology in Your Own Backyard. Reading, Massachusetts: Addison-Wesley. 1979.
Stories, suggested activities and games introduce the many facets of and the people involved in archeology.

About Women in the Social Sciences:

Bowman, Kathleen. The New Women in Social Science. Mankato, Minnesota: Creative Educational Society, Inc., 1976.

Russo, Nancy and O'Connell, Agnes. "Models from Our Past: Psychology's Foremothers." Psychology of Women Quarterly, Human Sciences Press, Vol. 5 (1). Fall, 1980.

About Careers:

Mead, Margaret. Anthropologists and What They Do. Eau Claire, Wisconsin: E.M. Hale, 1965.
Margaret Mead interviews her colleagues (15 men, 3 women), providing fascinating insights as one travels with Mead to see what anthropologists do and where they do it.

Parker, Rolland S. Psychology and Counseling Careers. New York: Franklin Watts. 1977.

Splaver, Sarah. Career Choices in Psychology. New York: Julian Messner, 1976. Discusses the field of psychology - professional and paraprofessional careers and allied professions.

For More Career Information Write:

American Anthropological Association, 1903 New Hampshire Ave., N.W., Washington, D.C. 20009. This agency maintains a list of digs sponsored by various anthropology departments. Some digs take student volunteers.

American Psychological Association, 1200 17th Street, N.W., Washington, D.C. 20036. ("Careers in Psychology" reprint available for 95¢)

American Sociological Association, 1722 N. Street, N.W., Washington, D.C. 20036.

Career Oriented Modules to COMETS Explore Topics in Science

TOPICS

- Health
- Biology
- Chemistry

Pharmacy

RESOURCE PEOPLE

- Pharmacist
- Chemist
- Medical Technologist

THIS MODULE

Activity I

"Drug Development" includes two activities which demonstrate how chemical properties of drugs must be considered in their development and packaging. Concepts introduced are emulsion (a liquid mixture of two ingredients which usually do not mix), efflorescence (loss of water), and deliquescence (absorption of water). The emulsion activity is brief and uses simple equipment. The second activity (as well as all others in the module) are primarily intended for pharmacists as resource people, but chemists could also be used with this activity. The drug development work of Florence Seibert (tuberculin) and Rachel Fuller Brown and Elizabeth Hazen (nystatin) can be related to this activity (see "Women and Drug Development").

Activity II

In "Drug Action" students test the effect of antiseptics on microorganisms grown in a nutrient medium or on bread. The materials are rather simple, but care must be exercised to prevent the inadvertent spread of germs. Several days of incubation are necessary. Students can practice experimental procedures in this activity. Medical technologists, microbiologists, and other health career people could be used with this activity. The work of Seibert, Brown and Hazen can be related to this activity.

Activity III

"Drug Interaction" emphasizes the pharmacist's role in alerting patients and physicians to possible detrimental interation of drugs with other drugs, food, or alcohol. The activity is brief and requires only simple equipment. The activity does not demonstrate an interaction of concern to pharmacists, but it can be related by analogy to their career. This activity would also be appropriate for chemists.

University of Kansas School of Education Department of Curriculum and Instruction

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RELATED MODULES

Pharmacy is primarily intended to demonstrate various aspects of the pharmacist's career. However, chemists could be used with the first and third activity, and medical technologists could be used with the second activity. Following are other modules which could be used by pharmacists.

Fit N' Trim

Students do an activity in human genetics.

Body Detectives

The various pH tests done by students relate to the pharmacist's understanding and use of pharmacology.

WHERE TO FIND RESOURCE PEOPLE

Pharmacists work in local drug stores, in the drug departments of larger chain stores, and in hospital pharmacies where they dispense medicine and advise the medical staff about drugs. Other pharmacists work in research, manufacturing, and marketing of drugs and are employed by large drug companies such as Squibb, Parke Davis, Merck, and so forth. Pharmacists are employed in governmental agencies such as the public health service, the Food and Drug Administration, and the military. Some pharmacists work as consultants to nursing home staff who may provide contacts to the pharmacists. Contact the nearest university which offers training in pharmacy (names of universities can be obtained from a local pharmacist or the American Association of Colleges of Pharmacy). A state or local chapter of the American Pharmaceutical Association may supply a resource person (write APA's national office for references to local and state groups).

Women and Drug Development

We like to think that tuberculosis has been eradicated. However, in 1978 TB struck three million people worldwide, including 29,000 Americans. In 1977 TB caused 3,000 deaths in the United States. The front line defense against tuberculosis remains the tuberculin skin test. People who have had or currently have an active tuberculosis infection produce a reaction to the tuberculin. Once identified, these people can receive medical treatment.

The currently used form of tuberculin, called PPD (Purified Protein Derivative), was developed in the mid-1930's by Dr. Florence B. Seibert. Tuberculin had been available since the 1890's when Koch initially developed the test, but the tuberculin produced by the Koch method did not produce reliable results. Sometimes a positive result was obtained in a person who did not have the disease. That was a big enough problem, but an even bigger problem arose because some cases were overlooked due to a false negative test.

The Koch tuberculin produced unreliable results, because the Koch method, salutary as it was, produced an inconsistent product. Florence Seibert, working on a team with support from the National Tuberculosis Association (who provide Christmas Seals), was able to produce tuberculin in a new way. Her technique consistently produced the same product, and this tuberculin consistently produced reliable results.

While Florence Seibert developed a technique to produce a drug for disease testing, Dr. Rachel Fuller Brown and Dr. Elizabeth Hazen developed a drug which combated disease. Nystatin, which is dispensed in several forms, combats fungal infection, which is more prevalent than often believed. Fungal infection accounted for 40% of hospital cases among American troops in Vietnam and nearly 80% of outpatient visits.

The warm, moist conditions prevalent in Vietnam encouraged fungal infections, but those diseases are not limited to tropical areas. Ringworm, which in one form is better known as athlete's foot but which definitely is not limited to the foot, is not a worm, but rather a fungal infection. The ring-shaped growth pattern, which gives ringworm its name, results from its being caused by a fungus; and we are familiar with the round shape of mold growths on bread, fruit, and cheese.

In addition to treatment of fungal infections of the skin, nystatin is used to treat moniliasis, a painfully sore mouth caused by an explosive growth of fungus sometimes resulting from treatments with antibiotics. The antibiotics are administered to combat bacterial infection. That's good; however, the antibiotics kill not only the problem bacteria but also other bacteria present in the mouth. These latter bacteria serve a useful function; they keep in check the mouth's fungus population.

Dr. Brown and Dr. Hazen made a good team. Elizabeth Hazen was a mycologist, one who studies fungus. From soil she isolated some streptomycetes, a microorganism which appeared to be antifungal. In turn, Rachel Fuller Brown, a biochemist, extracted from the streptomycetes the drug, which they named nystatin and which proved to be both antifungal and safe for human use.

As an interesting aside, Brown and Hazen arranged for the profits from nystatin to be plowed back into research. To date well over twelve million dollars have been derived for that purpose.

The work of Seibert, Brown, and Hazen can be related to Activity I, "Drug Development." Brown's and Hazen's development of nystatin can be related to Activity II where mold is grown and to Activity III where drug interactions are the topic. In the latter activity, point out that in some situations the positive attributes of antibiotics are accompanied by the negative consequence of fungal infection, and that that infection can be relieved with nystatin.

Activity I: Drug Development

Materials:

- Two jars (such as baby food jars).
- Vegetable oil.
- Liquid soap.
- Water.
- Measuring spoons and cup.

Procedure:

This activity demonstrates how oil is emulsified in water by soap. Analogously, pharmacists who work in drug development try to find emulsifying agents that will keep particular medicines from separating, just as unhomogenized cream separates from the rest of the milk.

Individuals or small groups of students could do this activity or the resource person could demonstrate the process of emulsification. If this activity is done as a demonstration, use more ingredients and larger jars that are more easily seen.

Add a teaspoon of oil to a half cup of water in each of two identical jars. Add one-half teaspoon soap to one of the jars. Tightly cap and vigorously shake both jars. In which jar does the oil separate most rapidly? (Soap is an emulsifying agent.)

At this point the pharmacist could relate this activity to drug development or move on to the extension activity. The work of Seibert, Hazen, and Brown (see "Women and Drug Development") can be mentioned at this point.

Extension Activity 1: Water Loss or Gain

Materials:

- Na_2CO_3 (sodium carbonate) powder. Also called sal soda or washing soda.
- NaOH (sodium hydroxide) pellets. (Caution: Do not touch these pellets. Handle with tongs, tweezers, or foreceps.)
- Balance (the more precise, the better).
- Filter paper.

Background Information:

Drugs must be packaged so that their potency will not be lost before they are dispensed. Some drugs are affected by light and must be stored in amber bottles; other drugs react with plastic and must be stored in glass containers. Pharmacists who work in drug development must find ways to package drugs.

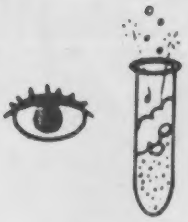
Procedure:

This activity demonstrates how two sodium compounds behave differently when exposed to air. One gains and the other loses water in air. Similar processes happen to improperly packaged drugs.

This activity should be started one day prior to the visit of the resource person by putting three teaspoons of Na_2CO_3 on a piece of filter paper and three teaspoons of NaOH on another piece. The weight and appearance of each should be carefully recorded. The two substances then should sit uncovered for 24 hours. Take great care to keep the materials where they cannot be accidently touched by anyone.

The resource person and/or teacher should reweigh the substances after 24 hours. The Na_2CO_3 will have lost weight by a process called efflorescence, and the NaOH will have gained weight by a process called deliquescence. (Actually, Na_2CO_3 is found in sal soda as the hydrated form, $Na_2CO_3 \cdot 10H_2O$, a combination of water and Na_2CO_3. When the sal soda is exposed to air, some of this water is given up. The NaOH undergoes the opposite process; the NaOH becomes hydrated when exposed to air, which contains water vapor. The exposed NaOH will become "runny" as it absorbs water.)

Activity II: Drug Action



Materials:

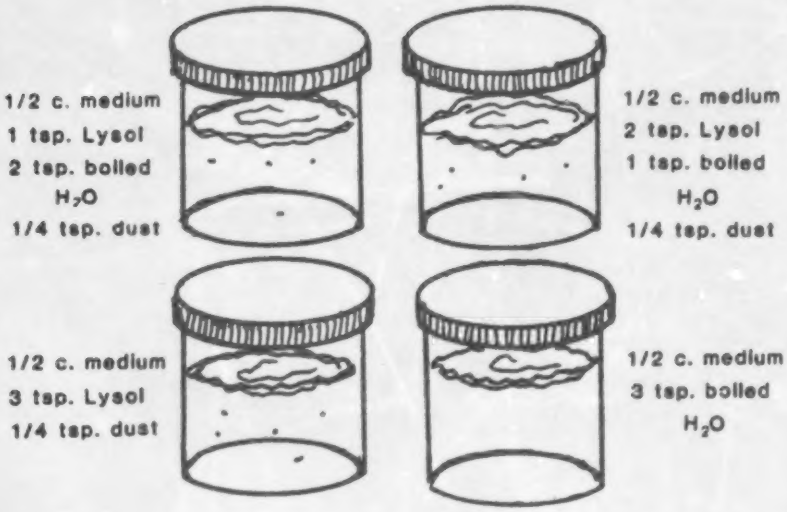
- Bouillon cube.
- Plain gelatin.
- Water.
- Several small jars (such as baby food jars) with tight lids.
- Large pot for mixing nutrients.
- Measuring spoons and cups.
- Hot plate.
- A selection of antiseptics such as rubbing alcohol, hydrogen peroxide, iodine, mercurochrome, lysol, or witch hazel.
- Masking tape.

Procedure:

This activity should be started five to seven days prior to the resource person's visit, so that it can be completed before the visit and commented upon by the resource person. Alternatively, this activity could follow the resource person's visit. Directions are given for one set of jars; but the experiment could be repeated by several groups of students, if sufficient materials are available.

Make a nutrient culture medium using multiples of ½ cup water, ½ teaspoon gelatin, and ½ teaspoon crushed bouillon cube. Bring the medium to a gentle boil for 15 minutes (to kill most but not all microorganisms in it). Sterilize the jars and lids in an autoclave or boiling water or wash in an automatic dishwasher at its highest temperature setting. Carefully pour the hot medium into the small jars, putting equal amounts of about ¼ to ½ cup in each.

To separate jars add zero, 1, 2, or 3 teaspoons of the various antiseptics you have collected. To each jar add sufficient boiled water so that each jar will have had three teaspoons added. Mix the medium and antiseptic. (For example, to the jar to which you added two teaspoons of antiseptic, also add one teaspoon boiled water to bring the total of added material to three teaspoons.) Sprinkle the surface of the medium in each of these jars with ¼ teaspoon dust. Tightly cover these jars with lids. From this point on, do not remove the lids. Put masking tape on each jar and mark the contents.


1/2 c. medium
1 tsp. Lysol
2 tsp. boiled
H_2O
1/4 tsp. dust
1/2 c. medium
2 tsp. Lysol
1 tsp. boiled
H_2O
1/4 tsp. dust
1/2 c. medium
3 tsp. Lysol
1/4 tsp. dust
1/2 c. medium
3 tsp. boiled
H_2O

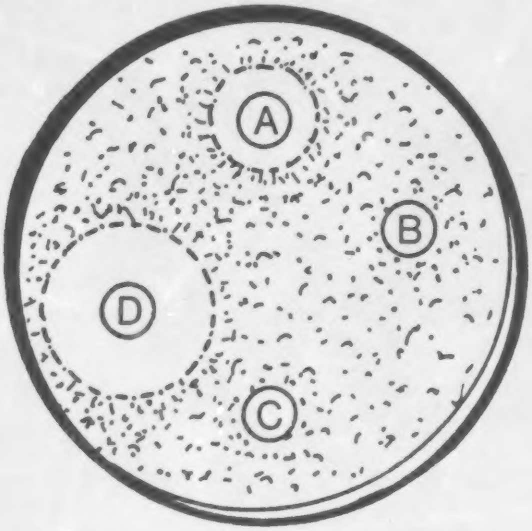
To an additional jar add three teaspoons boiled water but no dust. Cap and label this jar. All jars should be placed in a warm place (about 75°F) to incubate for two days.

After two days you should have patch-like colonies of bacteria, mold, yeast, and/or other microorganisms growing on some or all of the jars. Compare the growth of the colonies in the various jars. (The undusted jar may also show growth, since you are not using completely aseptic techniques, and some microorganisms may have survived the heating that was done.)

The jars can be kept two to seven additional days for observation. Remember, the jars should always remain tightly covered. (This precaution is suggested to reduce the chances of inadvertent infection from microorganisms growing in the nutrient and being wafted into the air when the lid is removed.) The jars and their contents should be disposed of in such a way that they will not be broken before they reach the garbage dump.

As your students study microorganisms in this or the extension activity, relate to them the work of Hazen and Brown to develop nystatin, an antifungal drug (see "Women and Drug Development").

The resource person can mention how drugs are tested to find which best kills particular organisms. Drug-impregnated paper discs are placed on the medium on which the organisms are growing. After a few hours or days, the drug developer looks for clear zones around the discs. If such a zone is present, that means the drug is inhibiting the organism and is a candidate for further testing as a drug for people or animals.

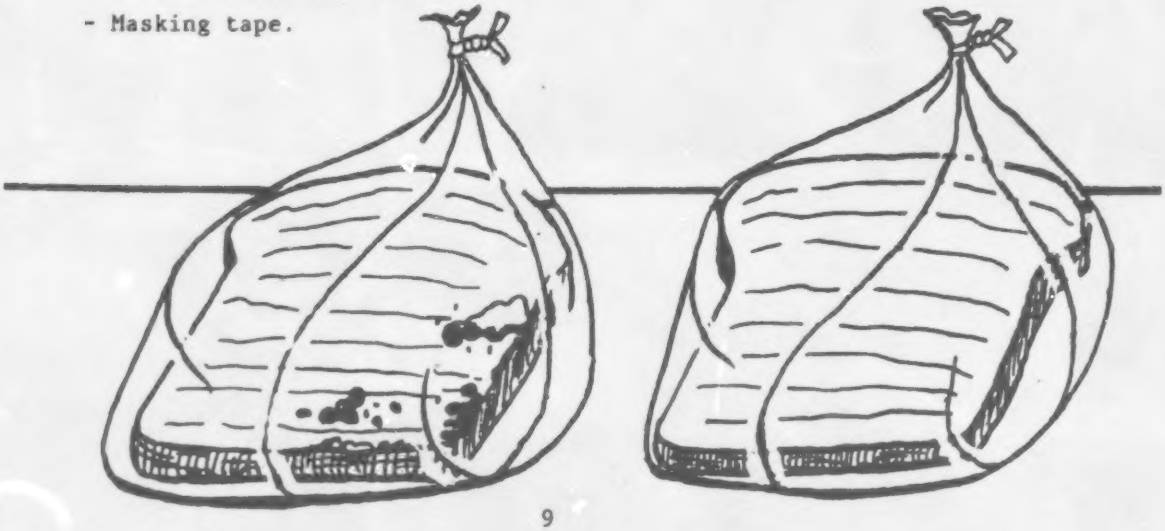


Petri dish

Alternate Activity 1: Bread Mold

Materials:

- Baggies or other plastic bags and ties.
- Homemade bread.
- Commercially baked bread.
- Masking tape.



Procedure:

This activity is simpler than the preceding activity but does not include a direct treatment with antiseptic. The antiseptic preservative will already have been included in the commercially baked bread. Because of this activity's simplicity, each student should be able to do this activity. This activity can be started seven to ten days prior to the resource person's visit or be done following the visit.

Place one piece of commercially baked bread in one plastic bag and a piece of homemade (untreated) bread in a second bag. Tie each bag, mark them with a piece of masking tape, and place all of them in a warm location (about 75°F). The bread can be observed daily for the appearance of mold colonies. Blue-green colonies may be a relative of the mold from which penicillin is extracted.

Activity III : Drug Interaction

Materials:

- Baking soda.
- Cream of tartar.
- Water.
- Three glass jars.
- Spoon.

Background Information:

One important job of the pharmacist is to advise patients and physicians on how drugs interact with other drugs, food, and/or alcohol within the body. In some cases, two drugs, which separately have a positive effect, together may have different and perhaps negative effects. This activity uses two common household products, baking soda and cream of tartar. This example of interaction can be related by analogy to drug interaction.

Procedure:

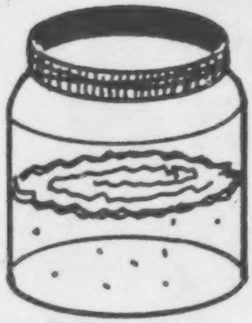
This activity can be done as a brief demonstration by the resource person, who can then talk about analogous examples of drug interactions which the pharmacist and physicians must avoid.

Add about a tablespoon of cream of tartar to a cup of water in a glass jar. (Amounts of materials are approximations; adding more will cause a more dramatic reaction. Using a larger jar and more materials will allow the demonstration to be seen more easily.) Stir the contents. Nothing spectacular happens.

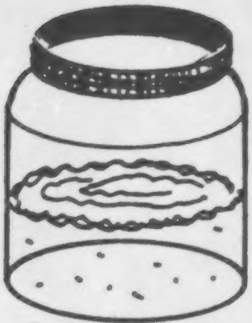
Stir about a tablespoon of baking soda in a cup of water in a second jar. Nothing spectacular happens.

Mix together equal amounts of dry cream of tartar and baking soda. Stir a tablespoon of this mixture into a cup of water in a third jar. The contents should fizz as carbon dioxide is produced. (Tartaric acid in the cream of tartar reacts with baking soda in water -- but not when dry -- to produce gaseous CO_2.)

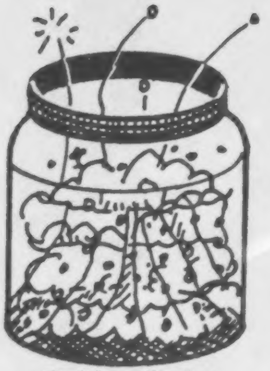
T



Baking Soda
+
Water



Cream of Tartar
+
Water



Baking Soda
+
Cream of Tartar
+
Water

One example of a deleterious effect from drug use is related in "Women and Drug Development" and can be mentioned to students. In some cases, antibiotics have both a positive effect (kill the bacteria causing the disease being treated) and a negative effect (kill the "good" bacteria which keep fungus in check in the mouth). Elizabeth Hazen and Rachel Fuller Brown developed nystatin, which can be used to treat the resulting fungal infection in the mouth.

Career Information

One of the most ancient of professions, pharmacy is dedicated to developing drugs for healing and comforting the sick. The majority of the 135,000 pharmacists work in commercial drugstores. Pharmacists prepare drugs from natural and synthetic sources for use in diagnosis, prevention, and treatment of diseases. Pharmacists have studied chemistry, biology, physics, and mathematics in high school and college. At an accredited school of pharmacy, they have taken specialized pharmacy courses such as pharmacology (the application of biological principles in searching for, testing, and applying new drugs) and toxicology (the science of poison). After the coursework and an internship, they have taken a licensing exam given by a state board of pharmacy.

Since most drugs dispensed by pharmacists are pre-mixed, the visible job of the pharmacist often becomes counting or measuring and labeling medicine.

However, all pharmacists must be intimately familiar with the formulas, pediatric and adult dosages, side effects, storage conditions, and special instructions for each drug, for one of their most important duties is to advise patients and physicians on the proper use of medicine. They must be especially aware of the possible interactions of drugs with other drugs, food, and alcohol, since drugs, which separately may have positive effects, taken together or with the wrong food or alcohol may have unintended harmful consequences. Today's pharmacist assists in research on new drugs in experimental settings such as cancer treating centers in order to find the most appropriate combination of drugs that is helpful but has the least side effects. The newest member of the health care team is the radio-pharmacist who prepares and dispenses radioactive drugs. Pharmacists must keep abreast of the proliferation of new drugs, new information about older drugs, and laws regulating the use of drugs.

Related Activities:

George, Frank. Science Facts: Astounding and Exciting Developments That Will Transform Your Life. New York: Sterling. 1978.

Shalit, Nathan. Cup and Saucer Chemistry. New York: Grosset and Dunlap. 1972.

Career Information:

Fay, John T. Pharmacy: A Synthesis of Sciences. Boston: D.C. Heath. 1964.

COMETS Profiles:

Marily Rhudy: Pharmacist.
This pharmacist pursues a busy, multifaceted career and home life.

For More Career Information Write:

American Association of Colleges of Pharmacy, Office of Student Affairs,
4630 Montgomery Avenue, Suite 201, Bethesda, Maryland 20014.

American Pharmaceutical Association, 2215 Constitution Avenue, N.W.,
Washington, D.C. 20037.

Career Oriented Modules to Explore Topics in Science

COMETS

TOPICS

Probability

Sampling

Biology

Chances Are

RESOURCE PEOPLE

Actuary (Insurance)

Mathematician

Science Researcher

THIS MODULE

Activity I

In "Flip the Coin" students learn how to figure both theoretical and empirical probability. One or two coins is the only required equipment. The activity can be brief or lengthened with an extension activity. Any resource person who uses probability can lead this activity.

Activity II

"Sampling to Make Predictions" points out how a sample is taken from the total population in order to determine characteristics of the entire population and to make predictions about the population. Some gathering of simple materials (e.g., tin cans) is required. The activity can be rather brief, but not as short as Activity I. Any resource person who uses probability and sampling can lead this activity. Activity I should be done prior to this activity.

Activity III

Four different examples of the use of probability are included in "Probability Applied." Resource people could use the application(s) most appropriate to their careers. Three applications require no special equipment; and the fourth application, "Mortality Table," requires only the reproduction of a worksheet for each student. This activity should be preceded by Activity I. Challenge Cards are included as an extension to this activity. The work of Emilie du Chatelet (see "Women and Mathematics") can be related to this activity or any other activity in the module.

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RELATED MODULES

Chances Are is intended for any resource person who computes or applies probability, but some particular activities are most appropriate for specific careers. Actuaries should consider using "Mortality Tables" in Activity III. A health career person who works with genetics concepts should consider using "Sickle Cell Anemia" in Activity III. Activity II's "Sampling to Make Predictions" is especially appropriate for a cross section of resource people from wildlife biologists to business people in marketing to social scientists who use surveys and similar techniques.

Since so many diverse career areas use concepts of probability, resource people, depending on their area, could be used in connection with almost all of the other modules. For example, the wildlife biologist could be used with this module or with Outdoor People.

Figures Don't Lie

Students learn concepts of estimation and interpretation of graphs. Fascinating activities and information about graphing are included in "Women and Graphs."

Information Manipulation

Some concepts - primarily dealing with classification - are taught and can be related to a computer's information sorting and processing activities.

Program It

Students first learn to make flow charts; and then they learn how flow charts are used to write computer programs for microcomputers in BASIC (a computer language). Microcomputers are becoming increasingly available in schools, homes, and businesses.

WHERE TO FIND RESOURCE PEOPLE

Actuaries are employed by insurance companies and can be found through companies' home offices (not the agent who sells insurance). Mathematics teachers can be found in schools, colleges, and universities. Wildlife biologists are employed by governmental agencies such as a fish and game commission. Consult the yellow pages under government. Larger companies involved with marketing employ people with statistical knowledge. Most people holding an MBA (Masters of Business Administration), an increasingly popular degree, have had statistical training and could relate these activities to their careers.

Women and Mathematics

Gabrielle-Emilie Le Tonnelier de Breteuil, Marquise du Chatelet-Lomont, born in 1706 in France, could have lived a frivolous life befitting the aristocratic status her name implies. Better known as Emilie du Chatelet, she did indeed enjoy luxuries unavailable to nearly all other French people; but she also acquired an education, unusual for a woman even of her rank, pursued an intimate relationship with Voltaire, and made available to Enlightenment France the Principia of Newton.

The new understanding of the scientific method revealed through Emilie du Chatelet's translation and analysis of the Principia influenced both physical and social science. Chatelet's intellectual peers reasoned that just as mechanical laws had been uncovered in the physical realm, so also mechancial laws could be discovered in the social realm. Once the laws had been revealed, they could be applied to improving the lot of everyone. For example, by varying the amount of education available to a child, that child's adult economic status might be affected. In order to more clearly show how physical laws were to be applied to social laws, this example might be restated, "Adult economic status, AES, is a function of a child's education, CD." Or, AES = $\int$ CE, (the symbol, $\int$, means "is a function of.")

More and more early adolescent students are aware of functions because their textbooks have introduced the idea of a "function machine." A function machine has three parts: (1) input (the numbers or symbols fed into the machine), (2) output (the numbers or symbols produced by the machine), and (3) the function rule (the arithematic or other type of directions for how to change the input into output). For example, the function rule could be "square the input." Then, for an input of 3, the output would be 9. Given two of the three parts of the function machine, the missing part can be derived.

Function machines are not limited to raw number inputs and outputs; the machine can also work on variables. Suppose the input was the variable, "height from which an object is dropped," and the output was the variable, "speed of the object at any point in time." As most of us know from experience, as the object falls it picks up speed - it goes faster and faster. Its speed is constantly changing; so it is difficult - if not impossible - to calculate the object's speed at any single point in time. How can you put a precise figure (say, 31.2 miles per hour) on something that is always changing?

In order to solve this kind of problem, a new mathematics had to be invented; and that's what Newton did. He invented calculus; because he needed it in order to work out the mechanical problems that he was studying.

Emilie du Chatelet did not invent calculus. What she did do, however, was translate Newton's version into French and added notes of explanation which opened up this powerful new mathematical tool to the Enlightenment philosophers on the continent. (To this day, her translation remains the only French version of the Principia.) Also, we cannot say that Emilie du Chatelet caused the French Revolution and the American Revolution; however, we can note first, the powerful influence of Enlightenment thought on both those events, and second, the importance of Chatelet's version of Newton's work in mechanics for the Enlightenment thinkers who struggled to apply physical laws to the social realm.

The work of Emilie du Chatelet can be related to each of the activities in this module, but most clearly to Activity III, "Probability Applied." She worked wth the mathematics of how variables are related. Your students in Activity III will work with how one variable, "chance that any one calculator is defective," and how it is related to (is a function of) a second variable, "proportion of defective calculators in a sample of all the calculators."

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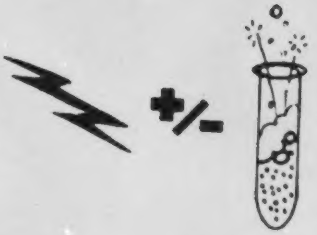
Activity I: Flip The Coins



Materials:

- One coin for each student.

Background Information:

Probability is the name applied to a measure of chance. For example, we might talk about the chances of getting an A on a test, inflation being less than 10% this year, catching a cold this month, making the basketball team, or getting heads when the coin is flipped. In each example, the word, "probability," could be substituted for "the chances of." Thus, we could say, for example, "What is the probability of getting an A?," and so forth.

Probability can be calculated in two different ways. Empirical probability is based on the observation of a large number of cases. The question is, "Among all the cases observed, how many times did thus-and-so happen?" In the case of empirical probability we do not know precisely the natural law governing why something happens; so our only recourse is to make many observations and then from these observations calculate the chances (probability) of each kind of event happening. For example, if you wanted to know what the chances are that a new student in school had a home computer, your only recourse would be to survey students in your school to find out how many had home computers. Then by division you could calculate the chances of any one student having a home computer:

General Formula for Empirical Probability

$$\text{Probability of a certain thing happening} = \frac{\text{Number of times the event occurred}}{\text{Total number of observations}}$$

$$\text{Probability of having computer} = \frac{\text{Number of students having computer}}{\text{Total number of students}}$$

If seven students out of 28 in your classroom have computers, then the chances of any one student having a home computer is:

$$\text{Probability of having home computer} = \frac{7}{28} = .25 \text{ (or 25\%)}$$

Theoretical probability can be calculated when the rules governing a particular event are known. In this case, no observations need to be made, although theoretical probability can be verified by observation. For our purposes here, we will limit theoretical probability to that represented by

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the following formula:

$$\text{Probability of a certain event happening} = \frac{\text{Number of ways that event can happen}}{\text{Total number of possible events that can happen}}$$

For example, what is the theoretical probability of getting heads when the coin is flipped? If you are flipping a coin, then there are two possible outcomes (events that can happen), either heads or tails will come up; and the likelihood of heads or tails is governed by chance. There's only one way to get heads, and that's for the head side to come up. Thus, we can calculate the theoretical probability:

$$\text{Probability of getting heads} = \frac{\text{Number of ways of getting heads}}{\text{Number of possible outcomes when flipping a coin}} = \frac{1}{2} = .50 \text{ (or 50\%)}$$

Note that it wasn't necessary to flip any coins to figure out this theoretical probability. We can verify our theoretical probability, however, by flipping coins and calculating the empirical probability of getting heads. The more times we flip the coin (i.e., the more observations we make), the better we would expect the empirical probability to approximate the theoretical probability.

Procedure:

Your resource person should have each student flip a single coin ten times and record the number of heads and of tails that occur. These observations can be pooled on the blackboard and the empirical probability calculated and explained by the resource person. Next, the theoretical probability of getting heads (50%) and tails (50%) could be calculated, explained, and compared with the empirical probability which was obtained.

Ask each student to calculate empirical probability for their own ten flips. Ask how many individuals obtained empirical probabilities closer to the theoretical probability than was obtained previously by pooling the class data. In most cases, the pooled calculation will be more accurate than most of the individual calculations, since the pooled calculation is based on more observations. The resource person should point out that more observations generally increase the accuracy of empirical probability.

At this point, if only a brief introductory activity is desired, resource people could relate how they use probability and sampling in their careers. Given more time, the resource person could also lead students in an extension activity; or the extension activity could be done after the resource person's visit.

Extension Activity 1: Checking Theoretical Probability

Materials:

- Two identical coins for each student.

Procedures:

Begin by having students figure out what outcomes they would expect if they flipped two coins. They should reply, "You could get two heads, two tails, or a head and a tail." Next ask, "What's the probability of any of these three outcomes occurring? For example, if you flipped the two coins, what is the chance of getting one head and one tail?" Students may reply one in three, one-third, or 33% (all three meaning the same thing), or they may reply one half, one in two, or 50%. Make certain both ideas, 33% and 50%, are expressed by the students and/or the resource person. Ask them how they could check their predictions; and then have them flip the coins 1000 times (i.e., each student should flip two coins enough times so that altogether the class makes 1000 observations). They should calculate the empirical probability of getting one head and one tail (i.e., divide the number of times a head and a tail came up by the number of flips made) and use this calculation to figure out which of their theoretical probability predictions (33% versus 50%) was correct.

Next, the resource person should have students look more closely at the theoretical probability of outcomes of flipping two coins. There actually are four possible outcomes: (1) coins A and B are heads, (2) coins A and B are tails, (3) coin A is head and B is tail, and (4) coin A is tail and B is head. However, when you flip coins, outcomes (3) and (4) appear the same -- one head and one tail. Now, calculate the theoretical probability of each outcome:

$$\begin{array}{l}\text{Probability of} \\ \text{two head}\end{array} = \frac{\text{Number of ways of getting 2 heads}}{\text{Total number of possible outcomes}} = \frac{1}{4} = .25 \text{ (or 25\%)}$$

$$\begin{array}{l}\text{Probability of} \\ \text{two tails}\end{array} = \frac{\text{Number of ways of getting 2 tails}}{\text{Total number of possible outcomes}} = \frac{1}{4} = .25 \text{ (or 25\%)}$$

$$\begin{array}{l}\text{Probability of} \\ \text{head and tail}\end{array} = \frac{\text{Number of ways of getting head/tail}}{\text{Total number of possible outcomes}} = \frac{2}{4} = .50 \text{ (or 50\%)}$$

Ask the class to compare their empirical probabilities with these theoretical probabilities. After this discussion, the resource people can describe how they use probability in their careers.

Activity II:
Sampling to Make Predictions

Materials:

- An opaque container for each two or three students. (Many school cafeterias can supply gallon cans. Used styrofoam coffee cups also work well after being cleaned out.)
- Ten poker chips, marbles, beads, pieces of paper, etc., of two colors for each can. (Different objects can be used in different cans; but within each can, all objects should be identical except in color.)

Advance Preparation:

Each can should contain one of three combinations of two differently colored objects.

Combination One: 5 of color one and 5 of color two.
Combination Two: 8 of color one and 2 of color two.
Combination Three: 2 of color one and 8 of color two.

If paper is used, wad each piece so it can be more easily picked up.

Procedure:

Prior to doing this activity, students should have done Activity I, "Flip the Coins," and the Extension Activity.

The resource person should tell students that there are two types of "creatures" living in each can and that the two can be distinguished by their color. Without looking into the cans, students should find out the proportion of each creature in their cans. They can "capture" (i.e., pick out) one creature at a time; but after each capture the creature needs to be returned to the can and the contents shaken before the next capture. Have students make 30 captures and record their results on the blackboard, as in this example.

Group	1	2	3	4	5	6	7	8
Color One	16	6	25	27	4	13	etc.	
Color Two	14	24	5	3	26	17		

Remind them not to look into their cans yet. After the data have been recorded, ask the students whether the contents of each of the cans were the same. They should justify their answers. (They should answer, for example, that group 1's can had about the same number of each creature, but groups 2's can held many more of color two.)

Ask them whether there's any similarity among the contents of the various cans. (They should answer that there seems to be three combinations, i.e., equal, more of one, and more of the other.)

Ask them how they each could calculate the chances of "capturing" a creature of one color or the other in their own cans. (They could calculate the empirical probability for both types of "captures.") Finally, ask how they could be even more certain of their predictions. (They could make more observations by either continuing to observe their own can in the same way or pooling data from all the groups with similar contents in their cans. With more observations, their empirical probabilities should approach the theoretical probabilities of 50-50, 20-80, and 80-20.)

At this point, resource people should relate how they use sampling techniques and probabilities in their own careers. Some resource people will actually have collected this kind of information in a very analagous fashion. For example, a wildlife biologist may have sampled an area to find the proportion of a certain animal with a particular characteristic. Other resource people may not have actually collected the data and calculated probabilities; but they have used probabilities. For example, an agricultural extension agent may deal with the chances of getting a certain amount of milk production by breeding two particular animals.

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Activity III : Probability Applied +/-

Materials:

- None (except for Application 4 which requires that each student have a copy of the Mortality Table Worksheet).

Procedure:

Prior to doing this activity the teacher should have lead the students through Activity I, "Flip The Coins." In doing this activity, a resource person could have students do one or more of the applications. The resource person, working with the teacher, can choose the application most related to the resource person's career and within the grasp of the particular student group.

Application 1: Sickle Cell Anemia

This problem is a direct application of Extension Activity 1, "Checking Theoretical Probability," in Activity I and relates to "More Information" in the module Fit N' Trim. Cystic fibrosis, discussed in Fit N' Trim, is similar to sickle cell anemia discussed here.

Sickle cell anemia, an inherited disease particularly prevalent among Blacks, is characterized by imperfectly shaped red blood cells (which gives the disease its name), poor circulation, suffering and early death. Like other genetic characteristics for which each individual receives one gene from the mother and one gene from the father, each individual has two genes controlling sickle cell anemia. If both genes are normal, then the individual will have no symptoms of sickle cell anemia. If both genes are the gene for sickle cell anemia, then the individual will have that disease. However, if an individual has one normal gene and one sickle cell anemia gene, then that individual will have an intermediary condition, called sickle cell trait, in which case only some of the red blood cells are imperfect and the circulatory problems are not nearly so pronounced as they are in the individual with sickle cell anemia. (Note that in cystic fibrosis (see Fit N' Trim) two characteristics are possible -- one either has the disease or doesn't have it. In sickle cell anemia three characteristics are possible -- the two extremes of having or not having the disease, plus the intermediary condition.)

Now to applying probability. Two people contemplating having children may want to know what the chances are of their child having sickle cell anemia.

If both parents are normal, then they can pass only the normal gene on to their children; and all of their children will be normal. Where both parents have sickle cell anemia, a very unlikely event, due to early death, all children will have sickle cell anemia. The more interesting situation, and the one where parents will more likely have questions about their potential offspring, is the case where one or both parents have sickle cell trait and the other or neither parent is normal.

Take the case of one parent being normal and the other parent having sickle cell trait. (It makes no difference whether the mother or father has the trait.) The normal parent has two normal genes and can only contribute a normal gene to a child. The other parent has one normal gene and one sickle cell anemia gene. To any child, this parent could contribute one gene or the other. What are the chances of conxributing a normal gene? That's a question of theoretical probability and can be solved thusly:

$$\text{Chances of contributing a normal gene} = \frac{\text{Number of ways to contribute a normal gene}}{\text{Number of different genes that can be contributed}} = \frac{1}{2} = .50 \text{ or } (50\%)$$

Similarly the probability of contributing a sickle cell anemia gene can be calculated as 50%. Thus, for this couple (one normal and one with sickle cell trait), the chances of conceiving a child with sickle cell trait is 50%. Likewise, there's a 50% probability of a child's being normal. (Remind students that just as the coins didn't exactly come up 50-50 heads and tails in Activity I, in individual families the proportion of kids with normal and sickle cell trait probably won't be 50-50.)

Now, how about families where both parents have sickle cell trait? Their situation is very similar to flipping two coins (see "Flip the Coins") where the probability of two heads was 25%, two tails, 25%, and a head and a tail, 50%). Since each parent has a normal and a sickle cell gene, each parent could contribute either a normal or a sickle cell anemia gene to an offspring. There are four possible combination of these genes for the newborn. The child could get (1) a normal gene from both parents, (2) a sickle cell gene from both parents (and thus have sickle cell anemia and not just the trait), (3) a normal gene from the mother and a sickle cell from the father, or (4) vice versa. In both outcomes 3 and 4, the offspring would have sickle cell trait.

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After reviewing all the preceding information with students, the resource person should ask what are the probabilities in this family of any particular child being normal or having sickle cell trait or sickle cell anemia. (Students should compute the theoretical probabilities to be 25%, 50%, and 25% respectively.)

Application 2: Quality Control

Suppose a manufacturer of hand calculators finds that six of each 1000 calculators were defective in some way. Ask students to figure out the empirical probability of getting a defective calculator. (They should figure out the probability is 6/1000 or .006 or .6%.)

Suppose that a department store purchased 500 of these calculators for resale. How many of these calculators would probably be defective? To figure this out multiply the total number of events that occur times the chances of the "desired" event occuring. In this case there are 500 events (i.e., calculators); and the chances of the so-called "desired" event (i.e., a calculator being defective) is .6%.

500 times .6% = 500 x .006 = 3 defective calculators expected

Assume that for each defective calculator returned, the department store would replace it with a new calculator free of charge. Assume the store paid $5 each for the calculators and resold them for $9. Ask students, "What profit would the store expect to make on these calculators?" (They paid $2500 for the calculators (500 calculators x $5/calculator = $2500). They would sell 497 calculators (500-3 defective ones) at $9 each for a gross sales of $4473 (497 x $9 = $4473). By substraction, their profit would be $1973 ($4473 gross - $2500 paid = $1973). Of course, the store will have to pay salaries, electricity bills, etc., so this isn't all profit.)

Application 3: Games of Chance

Suppose you entered a game offerred by a fast food chain where 480,000 game cards were given out and there were 1500 prizes. Ask students to calculate their theoretical probability of getting a prize. (Theoretical probability = 1500 winning cards ("desired" events) divided by 480,000 cards given out (total number of events) = one in 320 or a little over .3%.)

Suppose the chain's competitors had only 25 winners, but passed out only 600 cards. Ask students in which game they had a better chance of winning.

(The theoretical probability of winning in the second game is 25 divided by 600 or one in 24 or a little over 4%. Thus, the second game has many fewer prizes, but there is a much higher probability of winning.)

Application 4: Mortality Table

Materials:

- One copy of the Mortality Table Worksheet per student.

Procedure:

Begin by helping students read the table. They should see that the probability of a person's dying in any particular year is a function of the person's age and sex. A 15 year old boy's chance of dying during that year is 1.46 out of one thousand; but a 15 year old girl's chance is 1.26 out of one thousand. The table is based on observation, so it is an example of empirical, rather than theoretical, probability.

Ask students the chances of, say, a 53 year old man's dying that year (10.89 out of 1000), an eight year old girl's dying (1.12 out of 1000), and a 73 year old woman's dying (49.70 out of 1000). At this point, help students look at the brighter side by pointing out the chances of living out of a thousand are 1000 minus the chances of dying. Thus, a 13 year old girl's chances of living through that year are 1000 - 1.17 or 998.83 out of a thousand or 99.88% - pretty high odds!

Point out that the chances of a person's dying during any period greater than one year is calculated by adding together the probabilities of dying during each of the years in the period being studied. Take, for instance, the case of a 39 year old man. To calculate the chances of his dying during the next five years, add together the chances of his dying when he is 39, 40, 41, 42, and 43 (i.e., 3.25 + 3.53 + 3.84 + 4.17 + 4.53 = 19.32 out of 1000 or about 1.9%). Ask students to calculate the chances of a 57 year old woman's dying during her next five years. (11.90 + 13.00 + 14.21 + 15.54 + 17.00 = 71.65 out of 1000 or about 7.2%.)

Mortality tables are of particular interest to the insurance industry when they compute how much a customer should pay for life insurance coverage. Many factors are taken into consideration, but the premium (i.e., what the customer pays) is roughly a function of the chances of the customer dying during the time when the policy is in effect. Thus, comparing the premium to be paid on a five year policy for a 39 year old man and a 57 year old woman, the older woman would have to pay more than the man, because her chances of dying are greater. However, compare a woman and man of any age. The woman will pay less than the man for life insurance, because at any age her chances of dying are less than the man's chances. (This topic can make for lively discussion among students, but probably should be postponed until after the resource person's visit.)

Extension Activity 1: Challange Cards

Materials:

- Challenge Cards for each student (optional).

Procedure:

Following the resource person's visit (or in connection with that visit, if one of the Challenge Cards is particularly related to the resource person's career), pass out the Challenge Cards and have students investigate and report on the use of probability in each of the four problems.

Career Information

Most professional careers require a solid grounding in mathematics; so students should be strongly encouraged to study mathematics throughout high school, even if they do not plan to become mathematicians or statisticians or enter similar careers. Relatively few people do enter these careers. Information about mathematicians and statisticians can be found in Figures Don't Lie; and information about careers in computer science can be found in Program It. Information about actuaries is presented here.

How much a person should pay for insurance is the central concern of actuaries. Should young men and women pay more for auto insurance than older drivers? How much should the premium be for health insurance? Should life insurance be offered to a person who has had a heart attack? Each of these questions requires data about the relative risks involved. This module's Mortality Table Worksheet provides an example of the work of an actuary, for that table, which summarizes the chances of death for people by sex and age, would have been computed by an actuary.

Only 9000 people pursued this career in 1978 and a large proportion of those people were located in Boston, Hartford, New York, Philadelphia, and Chicago, the home cities of many insurance companies. Actuaries require a college education in mathematics and related areas such as computer science.

Related Activities:

Burns, Marilyn. The I Hate Mathematics! Book. Boston: Little, Brown. 1975.

St. John, Glory. How to Count Like a Martian. New York: Henry Z. Walck. 1975. Counting systems from those used by Egyptians and Mayans to those used on the abacus and computer are described and applied.

COMETS Profiles:

Joan Duea: Science Teacher, Writer and Consultant.
As well as teaching elementary school, Joan Duea is an author of science and math texts for elementary students, a consultant for Children's Television Workshop (developers of Sesame Street and 3...2...1 Contact), and a leader in professional teaching groups.

Judy Roitman: Mathematician
Originally majoring in English literature, Judy Roitman changed gears and entered mathematics teaching and research at the university level.

For More Career Information Write:

Society of Actuaries, 208 S. LaSalle St., Chicago, Illinois 60604.

See Figures Don't Lie for additional references.

Mortality Table Worksheet

.ge		
M	F	Mortality
	0*	6.20
	0	6.20
	1	1.67
	2	1.41
	3	1.35
	4	1.29
	5	1.24
	6	1.19
	7	1.15
	8	1.12
	9	1.11
	10	1.11
	11	1.12
	12	1.14
	13	1.17
	14	1.21
0*		7.08
0		7.08
1		1.76
2		1.52
3		1.46
4		1.40
5		1.35
6		1.30
7		1.26
8		1.23
9		1.21
10		1.21
11		1.23

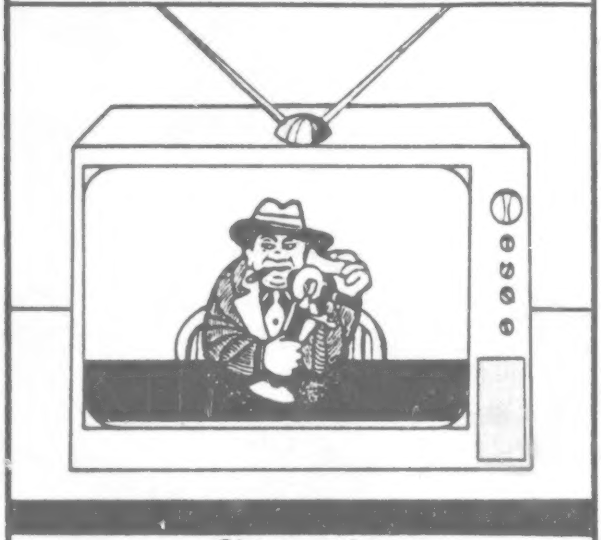
Age		
M	F	Mortality
12	15	1.26
13	16	1.32
14	17	1.39
15	18	1.46
16	19	1.54
17	20	1.62
18	21	1.69
19	22	1.74
20	23	1.79
21	24	1.83
22	25	1.86
23	26	1.89
24	27	1.91
25	28	1.93
26	29	1.96
27	30	1.99
28	31	2.03
29	32	2.08
30	33	2.13
31	34	2.19
32	35	2.25
33	36	2.32
34	37	2.40
35	38	2.51
36	39	2.64
37	40	2.80
38	41	3.01
39	42	3.25

Age		
M	F	Mortality
40	43	3.53
41	44	3.84
42	45	4.17
43	46	4.53
44	47	4.92
45	48	5.35
46	49	5.83
47	50	6.36
48	51	6.95
49	52	7.60
50	53	8.32
51	54	9.11
52	55	9.96
53	56	10.89
54	57	11.90
55	58	13.00
56	59	14.21
57	60	15.54
58	61	17.00
59	62	18.59
60	63	20.34
61	64	22.24
62	65	24.31
63	66	26.57
64	67	29.04
65	68	31.75
66	69	34.74
67	70	38.04
68	71	41.68
69	72	45.61

Age		
M	F	Mortality
70	73	49.79
71	74	54.15
72	75	58.65
73	76	63.26
74	77	68.12
75	78	73.37
76	79	79.18
77	80	85.70
78	81	93.06
79	82	101.19
80	83	109.98
81	84	119.35
82	85	129.17
83	86	139.38
84	87	150.01
85	88	161.14
86	89	172.82
87	90	185.13
88	91	198.25
89	92	212.46
90	93	228.14
91	94	245.77
92	95	265.93
93	96	289.30
94	97	316.66
95	98	351.24
96	99	400.56
97	100	488.42
98	101	668.15
99	102	1000.00

* The numbers in this column divided by 1000 equals the probability of a person dying at the age indicated. For example a female at age 41 has a probability of $\frac{3.01}{1000}$ or about $\frac{3}{1000}$ of dying during the year she is 41 years of age. Each mortality number can be rounded off to the nearest whole number for calculation purposes.

COMETS Challenge Card



Chances Are

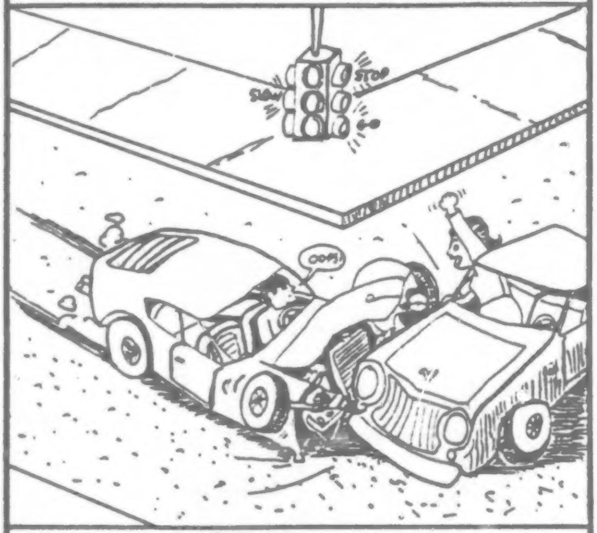
What TV show does the newspaper say is the most popular this week? How did they figure it out?

COMETS Challenge Card

Chances Are

According to the weather forecaster, what is the probability of precipitation tomorrow? What does "30% chance of rain" mean? How do they figure it out?

COMETS Challenge Card



Chances Are

Sometimes people who wear safety belts are hurt more in an accident than without belts. Yet we are advised to wear belts. How does probability affect auto safety?

COMETS Challenge Card

Chances Are

Talk with someone from your state's fish and game commission. Find out how they use probability to decide the limitations for hunting and fishing seasons.

Career Oriented Modules to Explore Topics in Science

Figures Don't Lie

TOPICS

Graphing

Sampling and Estimation

Data Interpretation

RESOURCE PEOPLE

Statisticians

Economists

Research Scientists

THIS MODULE

Activity I

In "Sampling to Make Predictions" students learn how to collect samples in order to estimate the size of an entire population and to make predictions. They sample a jar of beans (or other small objects) to estimate the populations of the two types of beans in the jar. Resource people in science careers such as wildlife biology or in nonscience careers such as marketing and public opinion surveying can relate the procedure learned in this activity to their jobs. Simple equipment is required, but some preparation time may be necessary.

Activity II

In "Graph Interpretation" students are given a graph of the dandelion population for each month from 1972 to 1979 with data for 1978 missing. They are required to ascertain the general pattern in the given data and predict the 1978 monthly population. The mathematical and scientific work of Hypatia (4th century) and Somerville (19th century) can be related to this activity. Information about these two women in the section, "Women and Graphs," includes some fascinating graphing exercises for students. Only student worksheets are required for Activity II, which can be chosen for resource people who require a brief activity.

Activity III

"Beware of Figures" presents students with some plausible, but also implausible data and they must figure out the error in reasoning in the data. Additional problems are included; and students can be assigned to collect sample advertisements to study claims made for the product. No equipment is necessary, but the sample problem may be made into an overhead transparency. This activity would be particularly appropriate in units on interpreting data or on evaluating oral and written communication.

University of Kansas School of Education Department of Curriculum and Instruction

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RELATED MODULES

This module is intended for resource people who use sampling techniques (Activity I), graphs (Activity II), or data interpretation (Activity III). These resource people could be found in almost any area of science and in other careers, too (e.g., business or communication). Therefore, depending on the specific career of the resource person you have in mind, any COMETS module may serve as an appropriate basis for their visit. The following selected modules are limited to mathematics and computer use.

Chances Are

Students learn some basic probability concepts and apply these ideas to problem solving.

Information Manipulation

Some concepts - primarily dealing with classification - are taught and can be related to the computer's information sorting and processing activities.

Program It

Students first learn to make flow charts and then learn how flow charts are used to write simple computer programs which use BASIC, a computer language, for microcomputers, which are becoming increasingly available in schools, homes, and businesses.

WHERE TO FIND RESOURCE PEOPLE

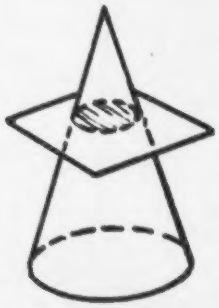
Contact a nearby college or university for scientists and mathematicians who use graphing, sampling, and other statistical techniques. Students majoring in math, science, or business could be used. High school mathematics teachers could use this module with your students. Field scientists in agencies such as a geological survey, fish and game department, or soil conservation service use these concepts. All engineers use graphs and could relate Activity II to their work. Contact your local Chamber of Commerce for references to organizations employing engineers.

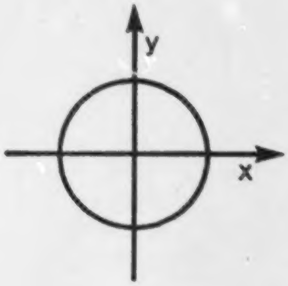
Major private employers of mathematicians include the aerospace, communications, manufacturing, computer, electrical equipment, financial, and insurance industries. If federal installations are close at hand, you may find mathematicians in offices of defense, air and space, education, agriculture, or human services.

Women and Graphs

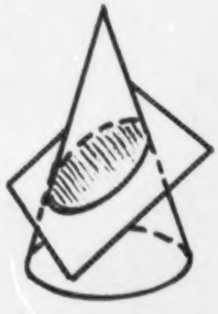
All sorts of scientists, engineers, and mathematicians rely on graphs. Curves on a graph can depict a chemical process for a chemist or chemical engineer, a weight/stress relationship for a physicist or mechanical engineer, a wildlife population projection for a conservationist or research biologist, an elliptical pattern for a mathematician or astonomer, and on and on. Graphs may be used to make predictions, or they may be studied for their own sake. The intrigue of geometric figures (curves) attracted the attention and study of two women, Hypatia and Mary Somerville, the former a fourth century citizen of Alexandria, Egypt, and the latter a nineteenth century Scottish woman.

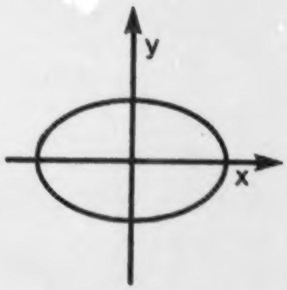
Hypatia, like many neoplatonists of her era, was fascinated with conic sections; and her works, which mostly remain as fragments of mathematical tracts, reflect this interest. Conic sections are generated where a plane intersects (cuts through) a cone. If a plane which is parallel to the base of a cone cuts through the cone, a CIRCLE is formed.



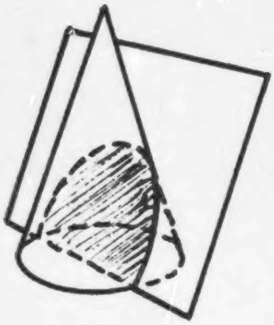


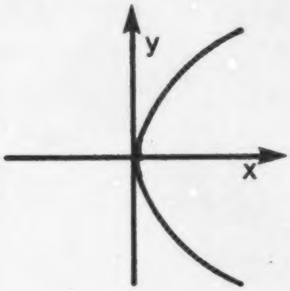
If this plane is tilted, it makes an ELLIPSE where it cuts through the cone.



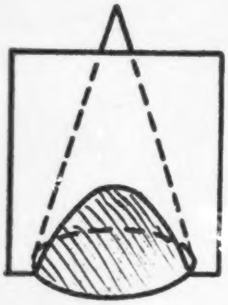


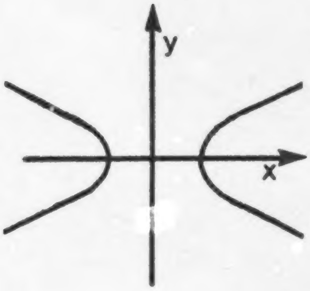
However, if the plane is tilted so that it is precisely parallel to one side of the cone, the intersection of the plane and cone is called a PARABOLA.





Finally, if the plane is tilted so it is parallel to the axis of the cone, the intersection of the cone and plane is called a HYPERBOLA.





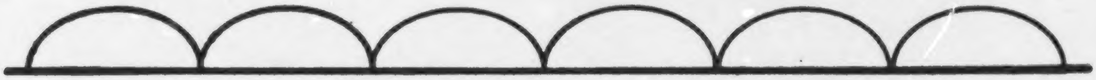
As shown in the illustrations, these conic sections can be graphed; and these graphs are not only interesting but also useful in understanding natural phenomena. For instance, the paths of planets about the sun can be described and their future positions predicted on the basis of an ellipse. The dish shaped TV antennas, with which students are familiar, as well as the mirrors in reflecting telescopes are parabolic in shape.

You can relate Hypatia's and her cohorts' work to Activity II, "Graph Interpretation," in which students study graphs and figure out their general pattern (as Hypatia contemplated conic sections). Students then make predictions, based on the pattern they discovered (as was done by Somerville, to whom we now turn).

Mary Somerville was notable not only in mathematics, but also in science, and not only as a theoretician but also as a popularizer of obtuse, theoretical ideas. She studied the path of the seventh planet, Uranus, which ought to follow an ellipse, and found irregularities in its orbit. She hypothesized the existence of an eighth planet which could pull Uranus out of its predicted orbit. Based on her writing which theorized a planet yet to be discovered, a young astronomer searched the skies where this planet ought to be located and found Neptune. At several points in this module you can relate how Somerville's prediction, based on observation and theory, led to Neptune's discovery.

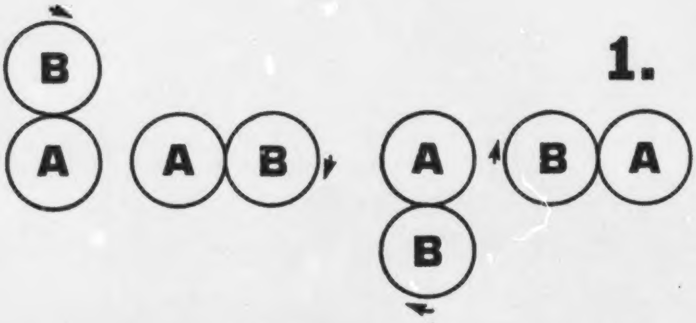
Her work, however, was not limited to theory; she also attempted to write about scientific and mathematical ideas so that everyone might understand them. (Isaac Asimov's writing serves a similar function today). One area of her writing extended the 1400 year old work of Hypathia with conic sections into the realm of studying motion (note the application of motion studies to Neptune's discovery). Somerville's work can be appreciated through an example which you can share with students, again in connection which the study of graphs in Activity II.

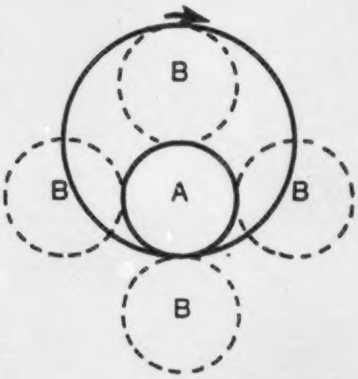
If you roll a circle along a straight line and note the path followed by one point on the edge of the circle as it rolls, you'll see what is called a cycloid.



What happens, though, when you move the circle in some path other than a straight line? To appreciate this problem, have students place two identical coins heads up on their desks as in the illustration, showing "coins" A and B.

1.





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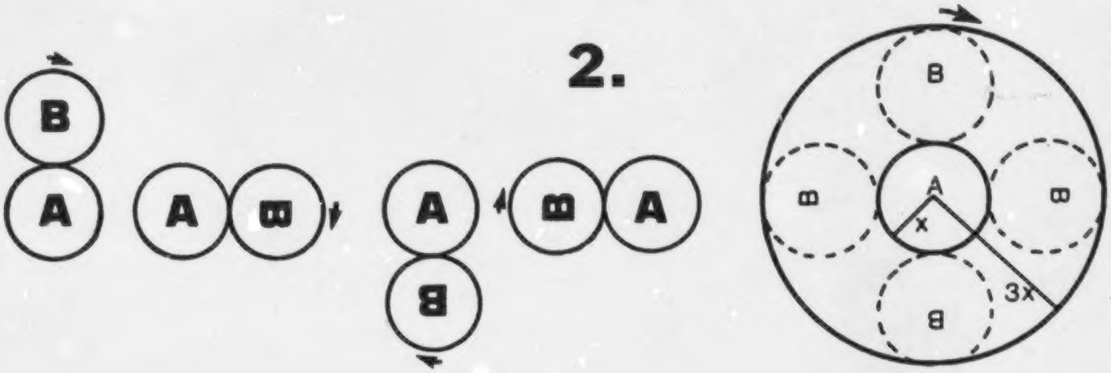
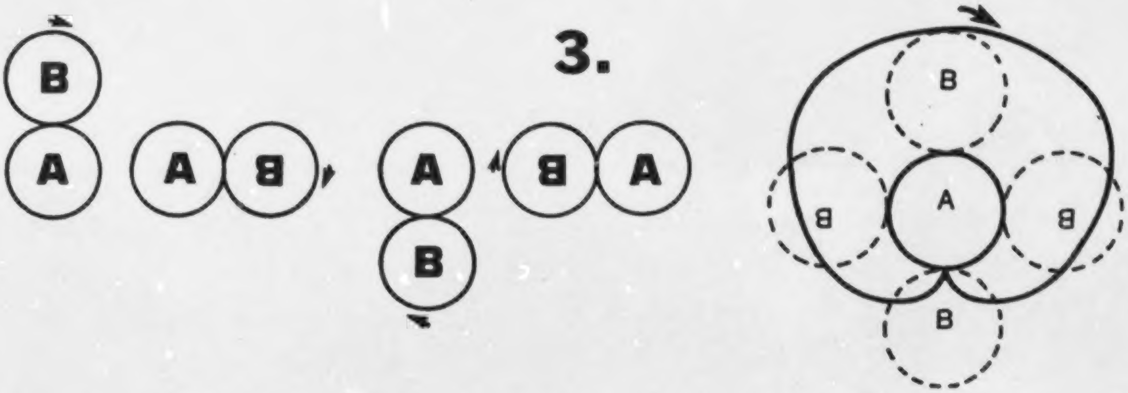
Have them move coin B clockwise around coin A but in three different ways. In other words, coin B is revolving around A. First, have B move (i.e., revolve) without rotating. See illustration 1 on preceding page. (Among other observations, they should note that they started with the bottom of B touching the top of A; but halfway around, the top of B was touching the bottom of A.)

2.



Second, have B revolve around A so that it always has its same spot touching A. (Among other observations, they should note that as B makes one revolution it also makes one rotation. We'll come back to that later).

3.



Finally, have B roll around A. (Among other observations, they should note that in this case B makes two rotations in its one revolution.)

Somerville, however, was not interested so much in the relative movement of the two coins, but rather in the motion of a point on the edge of B as it made its various revolutions about A. Have students repeat the same activities they did previously, but this time they should trace the path of a point on the edge of B.

As is shown in Illustration 1, when B revolves without rotating, a point on the edge of B traces a circle around A with a radius of two times A's radius and with the center of this circle on the edge of A. However, as shown in Illustration 2, when B simultaneously revolves and rotates, a point on the edge of B (opposite where A and B were initially in contact, i.e., tangent to one another) traces a circle, but this time its radius is three times the radius of A. Moreover, the center of this new circle is on the same point as A's center. In the third situation, however, shown in Illustration 3, the point on the edge of B no longer describes a circle, but rather a kind of heart shape.

These activities can be done just because they're intriguing. Also, they could be related to Activity II's graphing, as has been suggested; and/or they could be done to help students visualize motion.

For instance, referring back to Illustration 2 where the same spot on B was always kept in contact with A, this illustration can be related to the earth's and moon's relative movement. Students sometimes have difficulty understanding how the moon could be rotating, since it always keeps its same side towards us. Well, have them think of B as the moon and A as the earth. (Of course, the moon doesn't touch the earth, but that's not relevant. If that fact bothers students, have them repeat the activity with B not touching A.) As B revolves around A (analagous to the moon's 28 day revolution around the earth), B keeps its same side toward A (just as the moon always shows the same face to the earth). But as students noted earlier, B made one rotation as it made one revolution around A. Thus, the moon must make one rotation as it makes one revolution around the earth. If the moon didn't rotate, then its path would be similar to Illustration 1 and we would at some point each month see each side of the moon. We don't, so the moon must rotate.

Activities and information in this section are based on Teri Perl's Math Equals (Menlo Park, California: Addison - Wesley, 1978) and Susan Schacher's Hypatia's Sisters (Seattle: Feminists Northwest, 5038 Nicklas Place, N.E., 98105, 1976).

Activity I: Sampling to Make Predictions

Materials:

- Graph paper.

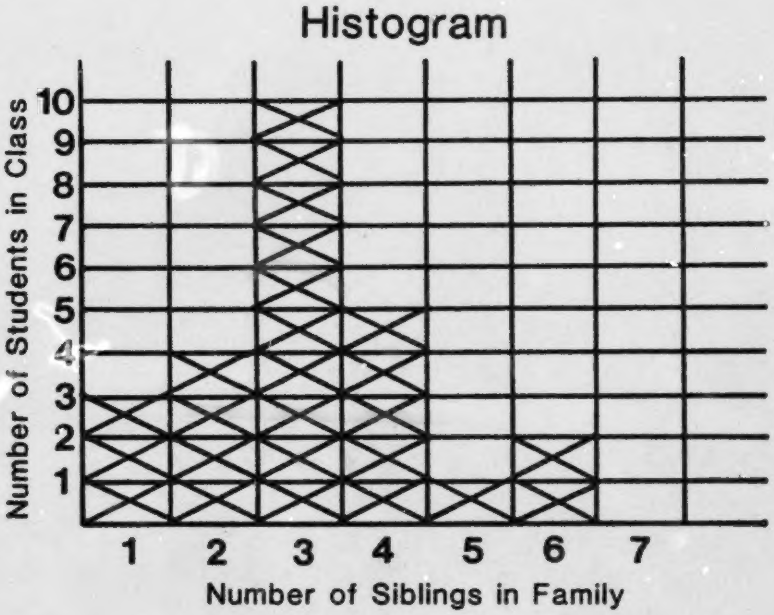
Procedure.

Begin by asking students for information on a topic of their choice. Some possible topics are:

- How far do you live from school? (Record data in terms of blocks, minutes, miles, or whatever unit is comfortable for students.)
- How many children are in your family?
- What is your favorite TV show? (Get five suggestions and then have each person vote once for their first choice from the list.)
- Who is your favorite singer? (Again, elicit suggestions and have students vote for one from five on a list.)

Record the data on a chart on the board and then have students draw a bar graph (histogram) depicting the data. After the data have been graphed, ask a question which can be answered from the graph. For example, how many students live more than a mile from the school? If a new student came to this class, what is the most probable number of children in that student's family?

Number of Siblings in Family	Students With This Number of Siblings
1	3
2	4
3	10
4	5
5	1
6	2



After interpreting the graph, the resource people should go on to describe uses of graphs in their careers.

After the resource person's visit is completed, students may want to ascertain how representative they are of students their age. They could collect the same data from another class in their own or a nearby school or from several distant states. After graphing data from the new group next to data from their own class, they should discuss whether any real difference exists between the two groups. No doubt some differences will exist; but point out to students the question is not whether there's any difference between groups, but rather the question is whether any difference was due to chance or due to some reason. Point out that that's one important question asked by people who use statistics and that there are many formulas which help people decide whether any differences are real.

Alternate Activity I

Materials:

- Large jar filled with two kinds of similar sized small objects mixed together in a two to one ratio. The jar should be quart to gallon sized. There should be too many objects to count easily. Objects could be things like navy and pinto beans, peanuts and almonds, or jelly beans and jawbreakers.
- Small vials, pill cups, or paper drinking cups (one per student).
- Measuring cups or spoons.

Procedure:

The resource person should ask students to estimate how many of each kind of object is in the jar. After collecting what will probably be guesses, discuss with students techniques for estimating the proportion and amount of each type of object.

One technique, which you can have students do, is divide the jar's contents among vials - one per student - and have individuals count the contents of the vials. Next, data can be compiled on the board. Students can then compute the percentage of each object in the jar (e.g., the jar is 41% pinto beans and 59% navy beans).

This technique becomes tedious if students have more than about 50 objects to count. To ease that problem, have students take from the jar a sample that can be counted. For example, they may measure the large jar and find it is a gallon in size; and they can take a one cup sample from the jar, being careful that it's a representative sample. Next, the one cup sample can be subdivided among vials and counted by individuals. The percentage of each of the objects in the one cup sample can then be computed.

To find out how many objects are in the large jar, have students compute what proportion their one cup sample was of the entire contents of the jar. If the jar contained one gallon of objects and they had counted a one cup sample, then they had counted one-sixteenth of the entire contents (there are 16 cups in a gallon). To find the number of each kind of object in the entire jar, have students multiply by 16 the number of each object in their one cup sample.

Other estimating techniques could be discussed, but this is a good time for resource people to talk about sampling and predicting procedures used in their careers.

Activity II: Graph Interpretation

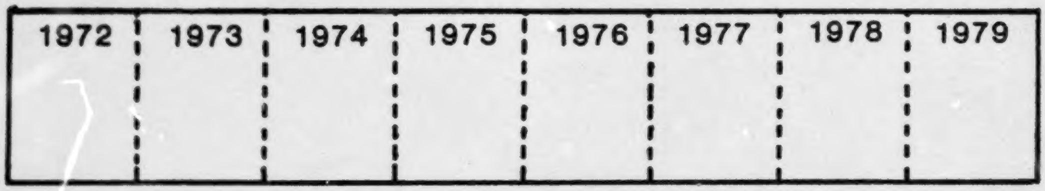
Materials:

- One copy of the worksheet for each student (last page of module).
- Scissors.
- Tape.

Procedure:

Give students a copy of the worksheet. Have them cut it apart and tape it together as indicated in the illustration. (This step could be done prior to the resource person's visit to save time.)

Graph 1: Number of Dandelion Plants Growing in Test Grass Plot

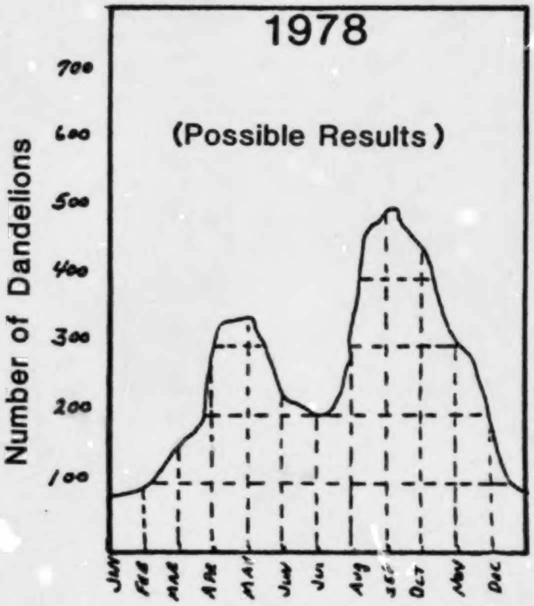


The resource person should tell the students that the graph shows data collected on the number of dandelion plants growing in a test grass plot. The number of dandelions growing in the test grass plot were counted each month for the time period indicated on the graph. Discuss the graph with the students. Questions such as the following should be asked.

1. What trends do you notice in the graph? (For example, two peaks per year; peaks occur at the same time each year; peaks get progressively higher in 1972-75; second peak lower than first in 72-75, but higher in 76-79.)
2. What months had the maximum number of dandelions each year? What is the average number of months between these "maximum growth" months?
3. Can you determine at least four variables that might have affected the results in the graph from 1972 to 1974? (E.g., moisture, temperature, daily length of sunlight, number of plants in preceding year, nutrients in soil.)

V

4. What results were observed in 1975? What do you suppose caused this occurrence? (The test grass plot could have been sprayed to kill dandelions; someone could have dug the dandelions out; or the weather conditions could have drastically changed.)
5. What number of dandelions would you have expected in 1978? Why? Complete the graph for 1978. (Here is a possible solution for 1978.)



6. What are some other situations that occur in cycles? Would graphs be useful to show trends or make predictions? Why or why not? (Tides, insect populations, economic recessions, and sun spots are examples.) Students may want to discuss the predictability of the suggested cycles. For example, are recessions as predictable as tides?

At this point resource people probably should move on to talk about their use of graphs and the need to understand and be able to interpret graphic data. However, at the first opportunity after the visit the teacher should relate the applications of graphing by Hypatia and Somerville (see "Women and Graphs").

Activity III: Beware of Figures

Materials:

- Copy of "How Many Days Do You Go To School?" for overhead projector or on blackboard (next to last page of module).

Procedure:

The resource person should show how "it can be proven" that students spend NO time in school. Show and briefly describe the data and calculations in the chart, "How Many Days Do You Spend in School?" (If an overhead projector is used, cover transparency with paper and slide the paper down to reveal one fact at a time.) Students, of course, will argue that the chart isn't true; so the resource person should ask students to figure out where the chart is incorrect. (There are duplicate subtractions. For example, days were subtracted for weekends and vacations; and eight hours per day, including weekends and vacations, were also subtracted.)

After discussing this sample problem, remind students that statistics can be used in positive and negative ways. (The preceding two activities have shown some positive applications of statistics.) Sometimes commercials and advertisements use statistics with hidden or hollow meanings in order to make a product sound attractive or effective. For example, an advertisement may say, "Experiments prove that a certain medicine kills millions of bacteria in a few minutes." It does not state what kind of bacteria were killed by the medicine; nor does it say how many were not killed. Maybe the ones killed are helpful bacteria that are completely harmless rather than a kind that can cause disease. Another thing to consider is the conditions under which the medicine kills the bacteria. Millions of bacteria can be killed in a few minutes by exposing them to sunshine. Thus, perhaps sunshine is a more effective germ killer than the advertised medicine. The commercial isn't necessarily lying, because its conclusion is indeed possible. However, other unmentioned conclusions are also possible; and perhaps the unmentioned possibilities are more valid than the one mentioned in the commercial.

Here's another example. Suppose an ad claimed that four out of five dentists surveyed recommend Brand A for their patients who use that kind of product. To figure out how much trust you'd put in that statement you may want to know how the dentists were chosen and how many were surveyed. Maybe only dentists who had stock in Brand A were surveyed. Perhaps what the dentists were really saying was "You shouldn't use that type of product, but if you feel you must, then Brand A is best."

Here's a third example of how statistics may be used to prove a point. People could say that teenagers today have more automobile accidents than they did in the "good old days." They may use these data to indicate that teenagers today are more careless. Before you decide that teenagers today are more careless than they were in your parents' generation, you must compare the data of the two generations. Perhaps there are more careless teenagers today because there are more teenagers, or more teenagers who drive cars now.

Whenever you see or hear statements based on statistics, stop and consider who collected the data, where the data were obtained, how they were collected, and what they really mean. Don't be fooled by clever ads based on inaccurate interpretations of data. A product is not necessarily superior just because a selected group of people say it is. The opinion of the "average" citizen is not always the "right" opinion.

After having provided the preceding type of examples and information, the resource person should ask students what is wrong with the conclusions obtained in the following examples. (Possible solutions follow each example.)

- More people were killed in automobile accidents in 1966 than in 1925. Therefore, automobiles were safter in 1925.

    SOLUTION - There were more automobiles in 1966 than in 1925. Statistics involving accidents per mile driven or in terms of percentages would be more appropriate.

- Brown cows produce 26% more milk than other cows. Therefore, brown cows are the best milkers and farmers should keep only brown cows.

    SOLUTION - Perhaps the brown cows were fed special food or given special treatment in some way. Perhaps brown cows cost more to keep, so their extra milk might not make up for their extra expense. Information about milk produced per dollar of expense would be more useful.

- Everyone that used Cold Away got over their cold in seven days. Therefore, Cold Away is a cure for colds.

    SOLUTION - Most people get over a cold in seven days without taking anything for it. More helpful information would be how well Cold Away performed in comparison to other medications and in comparison with no treatment.

At this point, resource people should share examples of data interpretation from their own careers. Following the resource person's visit, students could be asked to find ads or recall TV commercials which refer to statistics or experiments. They should evaluate the ads for use of statistics. Students should ask, "Is the ad's interpretation of the data the only possible interpretation, or are other interpretations possible?"

Career Information

People unprepared to study calculus in college exclude themselves from at least half of all possible collegiate majors. Not only do people majoring in mathematics, computing, science, engineering, and architecture need solid math preparation; but also students majoring in business, agriculture, criminology, political science, health, and many areas of education increasingly must have received a strong high school mathematics background prior to entering these majors. THE STUDY OF MATHEMATICS SHOULD NOT BE LIMITED TO THE PROSPECTIVE MATH OR SCIENCE MAJOR.

Mathematics as a career is pursued by a relatively small, but significant, number of people. In 1978 three-quarters of America's 33,000 mathematicians were employed at colleges and universities. Another 23,000 were employed as statisticians, mostly in the private sector. (By comparison, there were 430,000 computer programmers and systems analysts and another 666,000 computer operating personnel.)

The work of mathematicians can be roughly divided into pure and applied areas, although the distinction - as it is in science - is fuzzy at best. Pure mathematicians identify and solve problems with little or no concern for practical application, although, of course, others usually find ways to apply new discoveries, often with strikingly positive results. The rotating coins activity described in "Women and Graphs" is an example of pure math. Applied mathematicians are more concerned with the practical, problem solving outcomes of their work. The problem may be in science or economics or defense or engineering or any walk of life. Most statisticians are also applied mathematicians in that they often sample populations in order to make predictions or draw conclusions about these populations. For example, statisticians in business may sample Americans aged 12-15 to advise their marketing department about where to focus an advertising campaign.

V

Mathematicians and statisticians need at least a bachelor's degree; and graduate training is required in many areas. For applied mathematicians experience and/or education in the area of application (e.g., agriculture) is valuable.

Particular note should be made that at the time of this writing a critical shortage has been developing in middle and secondary school mathematics teaching. According to the National Council of Teachers of Mathematics, about ten percent of mathematics teaching positions are vacant; and this situation is expected to worsen.

Related Activities:

Peas and Particles Published by McGraw-Hill Book Company, 1221 Avenue of the Americas, New York, New York 10020. Several activities dealing with estimation are included.

About Women and Mathematics: (for the teacher)

Kaseberg, Alice; Krienberg, Nancy; and Downie, Diana. Use EQUALS To Promote the Participation of Women in Mathematics. Berkley: Lawrence Hall of Science, University of California. 1980.

Perl, Teri. Math Equals. Menlo Park, California: Addison-Wesley. 1978.
Nine biographies of women who made fundamental contributions in mathematics plus related mathematics activities to introduce middle level and other students to the women's areas of mathematics. This book would be difficult for most early adolescents, but it could be used with teacher assistance. Although not available as of this writing, Education Development Center (55 Chapel Street, Newton, Massachusetts 02160) should soon be marketing a similar book by Perl for younger readers.

Osen, Lynn M. Women in Mathematics. Cambridge, Massachusetts: MIT Press. 1974.
Biographies of eight women mathematicians plus essays on women and mathematics.

COMETS Profiles:

Joan Duea: Science Teacher, Writer and Consultant.
As well as teaching elementary school, Joan Duea is an author of science and math texts for elementary students, a consultant for Children's Television Workshop (developers of Sesame Street and 3...2...1 Contact), and a leader in professional teaching groups.

Judy Roitman: Mathematician.
Originally majoring in English literature, Judy Roitman changed gears and entered mathematics teaching and research at the university level.

For More Career Information Write:

American Mathematical Society, P. O. Box 6248, Providence, Rhode Island 02940.

American Statistical Association, 806 15th Street, N. W., Washington, D. C. 20005.

Mathematical Society of America, 1225 Connecticut Avenue, N. W., Washington, D. C. 20036.

National Council of Teachers of Mathematics, 1906 Association Drive, Reston, Virginia 22091.

Society for Industrial and Applied Mathematics, 33 South 17th Street, Philadelphia, Pennsylvania 19103.

Worksheet:

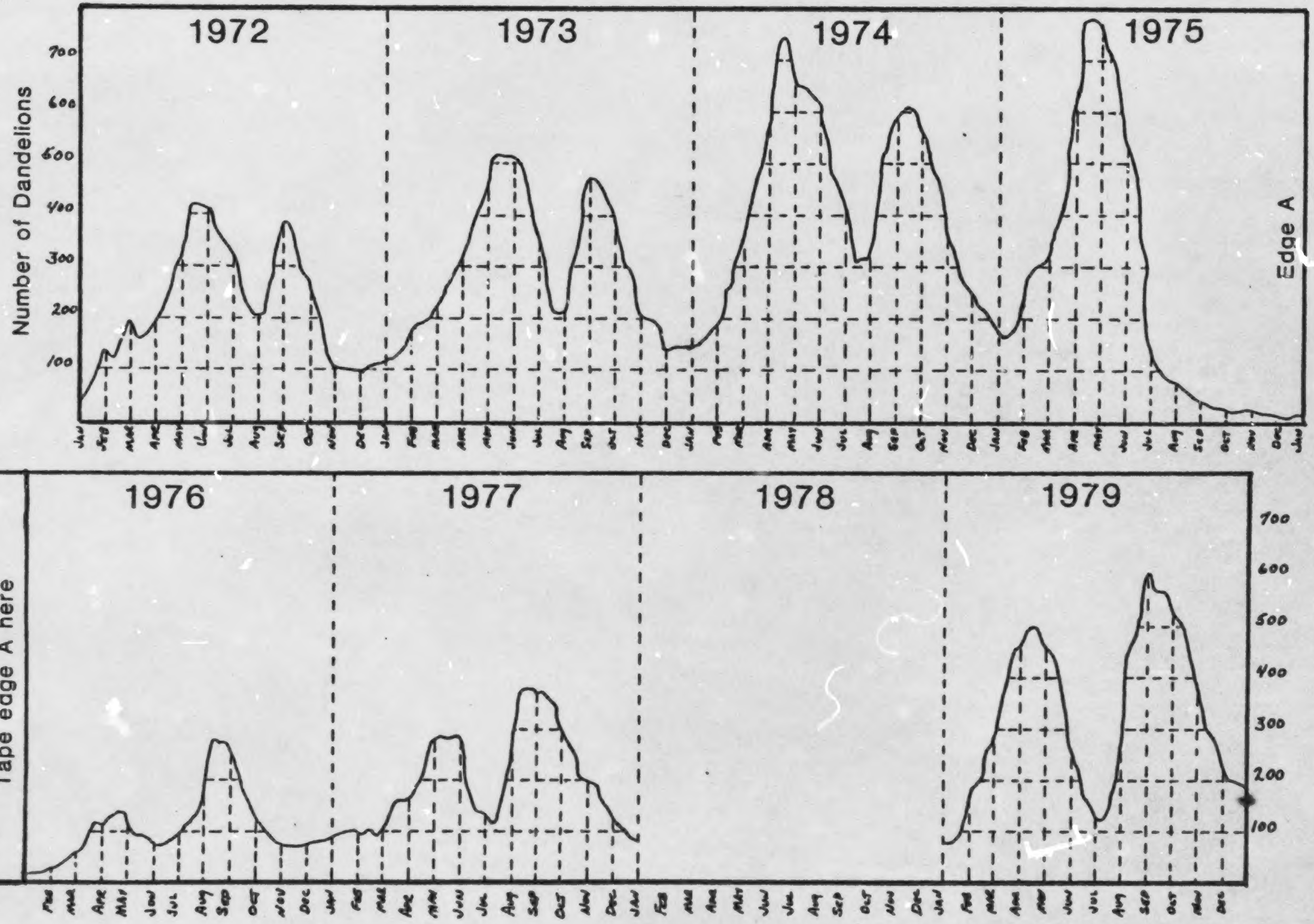
HOW MANY DAYS DO YOU GO TO SCHOOL?

Days in a year.	365
You sleep about 8 hours per day. (1/3 day X 365=122)	-122
Which leaves	243
You do not go to school on weekends. (2 days X 52 weeks=104)	-104
Which leaves	139
You have three months off in the summer. (3 months x 30 days = 90)	-90
Which leaves	49
You have at least two weeks vacation during the year. (2 weeks x 7days=14)	-14
Which leaves	35
You watch about two hours of TV per day. (2 hrs. x 365 days ÷ 24=30)	-30
Which leaves	5
You spend at least 20 minutes per day eating. (1/3 hr. x 365 days ÷ 24 = 5)	-5
Which leaves	ZERO

days in school

Worksheet:

Graph 1: Number of Dandelion Plants Growing in Test Grass Plot



Career Oriented Modules to COMETS Explore Topics in Science

TOPICS

Computer

Classification

Information Manipulation

RESOURCE PEOPLE

Systems Analyst

Computer Programmer

THIS MODULE

Activity I

"Common Characteristics" teaches students a system of binary classification and provides practice examples. The activity is particularly appropriate for systems analysts as an example of problem solving needed in sorting information. Materials are simple. The activity can be started by the teacher prior to the resource person's visit, if the resource person desires a brief activity.

Activity II

In "Sorting Information" students learn to mechanically sort information, thus applying and speeding up the binary classification skills learned in Activity I. Materials are simple, but require some preparation. Since the activity is not brief, the teacher may do the activity prior to the resource person's visit.

University of Kansas School of Education Department of Curriculum and Instruction

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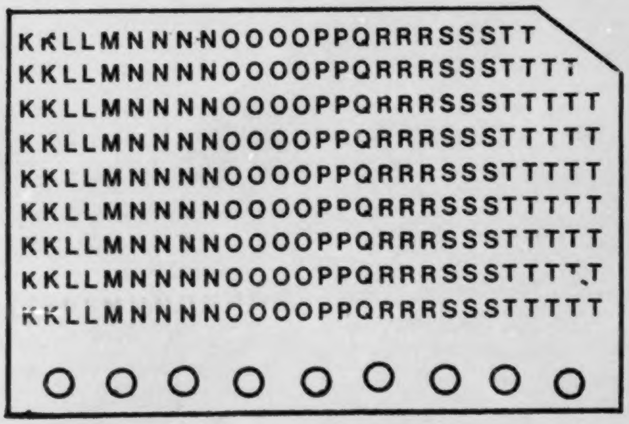
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RELATED MODULES

Information Manipulation is intended for systems analysts and computer programmers to demonstrate some very simple principles used in the storage and retrieval of information for the computer. This module does not directly introduce students to the computer or programming. Program It provides such an introduction.

Program It

Students first learn to make flow charts and then learn how flow charts are used to write simple computer programs which use BASIC, a computer language, for microcomputers, which are becoming increasing available in schools, homes, and businesses.

Women and Computers

See Program It for information about Ada Lovelace and Grace Hopper, two women who made fundamental contributions to computer programming.

Career Information

See Program It for information about the various computer careers.

Bibliography

See Program It for references.

WHERE TO FIND RESOURCE PEOPLE

Many school systems have their own computer staff or teachers who may serve as resource people. Contact local businesses, governmental agencies, or hospitals, many of whom employ computer personnel. If they do not have their own staff, they may refer you to computer service agencies whose business is to supply computer services. Computer stores may provide resource people or references to computer club members or others with a vocational or avocational interest in computers.

Activity I: Common Characteristics

Materials:

- One copy of each worksheet for each student or a copy of the worksheet made into an overhead transparency.

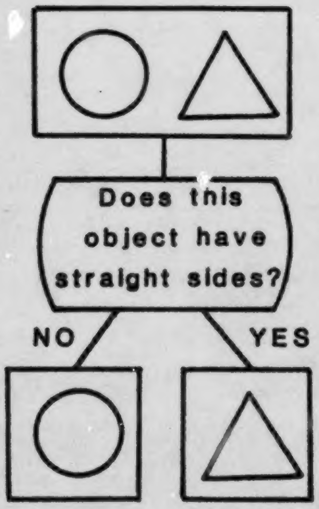
Background Information:

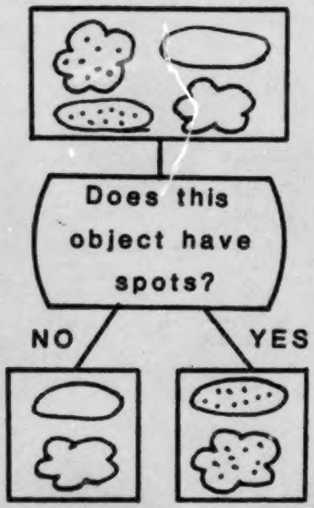
This activity is intended for the systems analyst (or any computer user who also does the systems analyst's job). This person must look at a problem and devise a solution, which in turn can be translated by a computer programmer into a form the computer can handle. One frequent type of problem faced by systems analysts is sorting or classifying information, and that's the common theme running through the activities in this module.

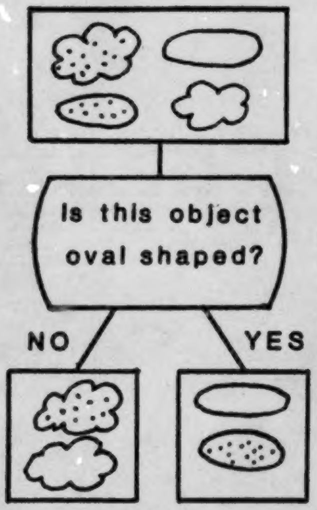
Procedure:

Begin by pointing out to students that as they unconsciously or consciously name objects, they are classifying or sorting objects. For example, when looking at two objects, a circle and a triangle, they unconsciously ask themselves a series of yes-no questions, the answers to which enable them to name the object. Does the object have straight sides? Does the object have three sides? Are all points on the edge equidistant from the center? These questions enable the asker to sort objects into their proper category and then give them a name, triangle or circle.

Proceed next to tell the students that the systems analyst often does not have a ready-made system for sorting objects; a sorting procedure has to be devised. For example, these four objects would be classified into objects with spots or lacking spots. However, they just as well could be sorted into

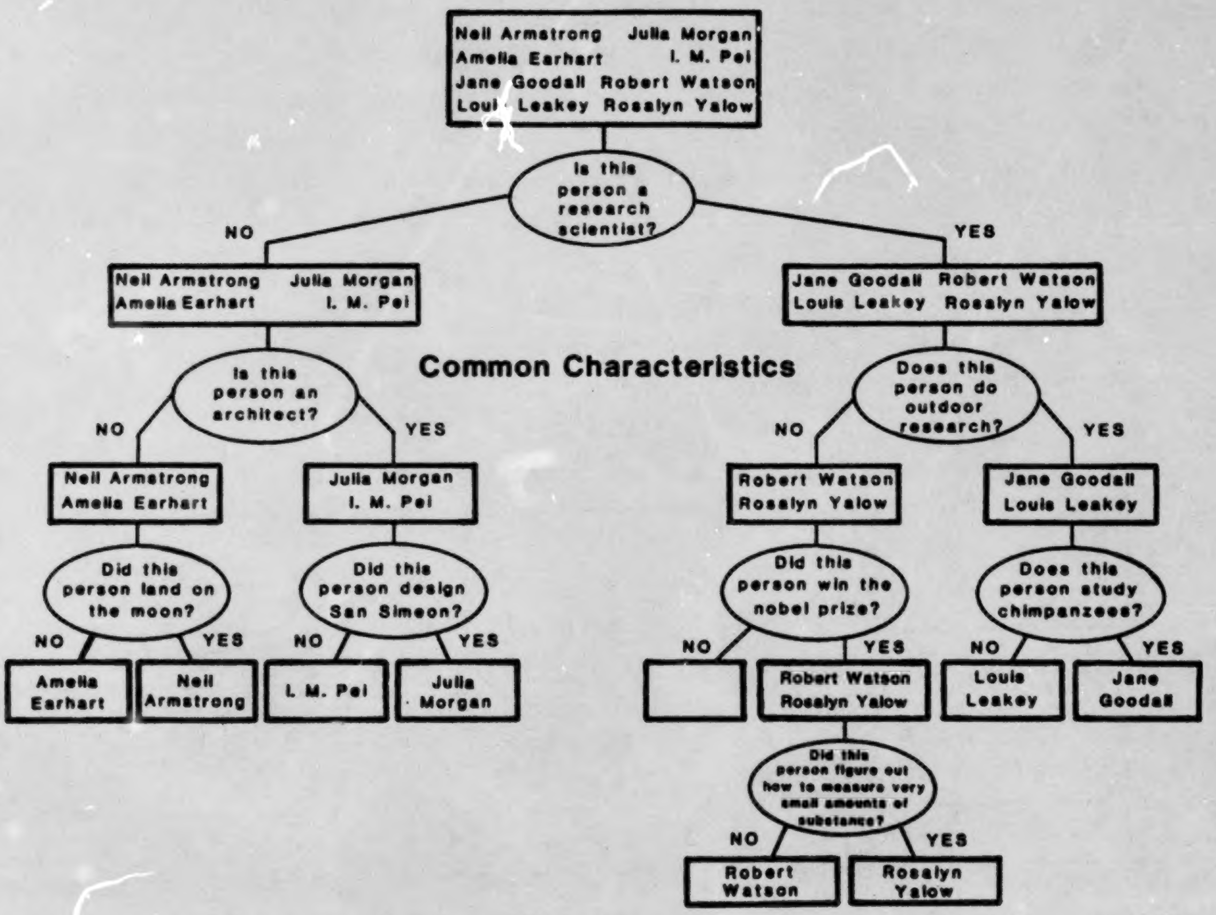






objects that are oval-shaped and those that are not. What the systems analyst has to decide is which method of sorting would be most useful in solving the overall problem being considered.

In most cases more than one characteristic must be used in order to sort objects into categories. For example, one couldn't look at all the cars in a parking lot and use one characteristic to sort all the cars into categories which reflect what company made each car. This illustration can be used to make the same point sorting people instead of cars. Point out that for each group of people, starting at the top of the chart with the entire group of


Common Characteristics
Neil Armstrong Julia Morgan
Amelia Earhart I. M. Pei
Jane Goodall Robert Watson
Louis Leakey Rosalyn Yalow
Is this person a research scientist?
NO
YES
Neil Armstrong Julia Morgan
Amelia Earhart I. M. Pei
Jane Goodall Robert Watson
Louis Leakey Rosalyn Yalow
Is this person an architect?
NO
YES
Does this person do outdoor research?
NO
YES
Neil Armstrong
Amelia Earhart
Julia Morgan
I. M. Pei
Robert Watson
Rosalyn Yalow
Jane Goodall
Louis Leakey
Did this person land on the moon?
NO
YES
Did this person design San Simeon?
NO
YES
Did this person win the nobel prize?
NO
YES
Does this person study chimpanzees?
NO
YES
Amelia Earhart
Neil Armstrong
I. M. Pei
Julia Morgan
Robert Watson
Rosalyn Yalow
Louis Leakey
Jane Goodall
Did this person figure out how to measure very small amounts of substance?
NO
YES
Robert Watson
Rosalyn Yalow

eight, a yes-no question is asked about some characteristic of the people in order to sort the people into two subcategories. Members of one subcategory have the characteristic; members of the other subcategory do not. The trick is to ask questions about relevant characteristics which indeed will help sort the people into subcategories. Note that the first question, "Did this person win the Nobel Prize?," asked about Watson and Yalow did not distinguish between the two people. The next question did the job. For your use, here's a little more information about each of these people.

Neil Armstrong	First person to set foot on the moon.
Amelia Earhart	Early pilot who made many notable transoceanic and transcontinental flights. (For more information, see Through the Air.)
Jane Goddall	Studied and wrote about chimpanzees. (See Outdoor People.)
Louis Leakey	Unearthed much evidence of prehistoric people and near relatives. (See Third Dimension.)
Julia Morgan	Architect for San Simeon, the palatial California estate of William Randolph Hearst. (See Constructions.)
I.M. Pei	Architect for the East Building of the National Gallery of Art in Washington, D.C.
Robert Watson	Co-discoverer of DNA's structure for which he won a Nobel Prize. (See Misc. Materials.)
Rosalyn Yalow	Co-developer of radioimmunoassay, a technique for measuring extremely small quantities of material, for which she won a Nobel Prize. (See Body Detectives.)

Next, give students Worksheet 1 which depicts quads. Alternatively, the worksheets could be made into overhead transparencies and shown one at a time. Ask what characteristic distinguishes quads from other objects. (Quads are aptly named; they have four sides.) Ask students which objects in the last row are quads. (A, D and E.) Give students some or all of the remaining worksheets and ask them to (1) identify the distinguishing characteristic of each type object and (2) pick out the named object in the last row. A key for the worksheets appears on page 6.

W

Worksheet	Characteristic	Example
2	Quirls have one tail attached and one small circle inside.	A, D, G
3	Selts contain two closed shapes with at least one small triangle inside each closed shape.	B, F
4	Whodoodles contain a small black circle inside any triangle making up each figure.	B, C, D
5	Tellubes have the same number of small shapes (circles, triangles, or squares) somewhere inside the whole figure as there are closed shapes (curves making up the figure).	C, D, E, F
6	Zons have as many lines of "shading as small objects in the entire figure. (Note that D has zero lines of shading and zero small objects in it.)	A, B, D

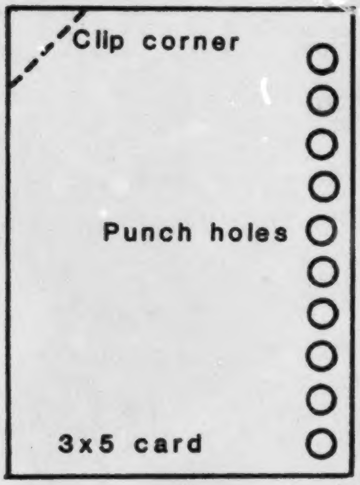
Activity 2: Sorting Information

Materials:

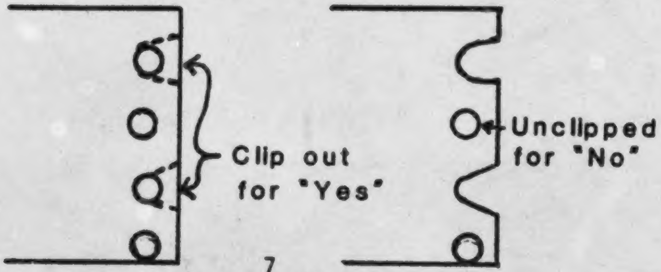
- For each student a 3" x 5" or similar card with holes evenly spaced and punched along a long edge (punched with a hole punch) and one corner clipped.
- For each 4-6 students a paper clip straightened out.

Procedure:

Students should have completed Activity I or other activities dealing with binary classification before doing this activity. The punched and clipped cards should be prepared before class to save the resource person's time To further save the resource person's time, this activity could be done prior to the visit; and the resource person could begin by relating this activity to their career.



Tell students that the sorting and identification of objects in Activity I can be done in a more mechanical fashion through the use of cards and a wire. Draw a card on the blackboard and show how information about an object in the form of a series of yes-no questions could be stored on cards. As an example, show students how the chart used to sort eight people in Activity I could be put on the card as a series of yes-no questions. Eight cards, one for each person, would have to be prepared; but for each person (card), each hole would have to contain the information for the same question. Hole one could contain the answer to the question, "Is this person a research scientist?" On the board write this question next to hole one. If the answer to the question is yes for the person (card), the space between hole one and the edge of the card could be clipped out, as is shown in the illustration. If the answer to that questions were no for the person (card), the edge of the

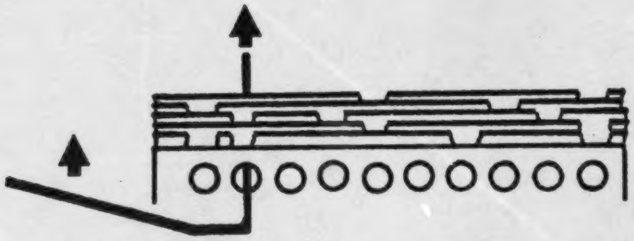


card next to hole one would not be clipped. On the board write, "Yes = Clip. No = No clip." If you were preparing cards for Rosalind Yalow, Robert Watson, Louis Leakey, and Jane Goodall, hole one would be clipped on all four cards, since each of these people is a research scientist. Hole one for the other four people (cards) would not be clipped.

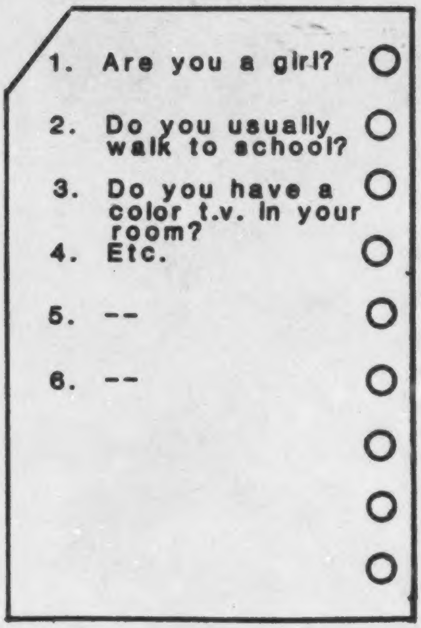
Hole two could be used for the question, "Is this person an architect?" Only cards for Julia Morgan and I.M. Pei would be clipped; the other six cards would not be clipped next to hole two. Point out that for each card each hole has to be clipped or not clipped. Even if the question on the chart did not affect one or more of the people, the answer to the question must be stored in the card.

Point out to students that in this example six more holes (questions) would have to be designated. Hole three could represent the question, "Did this person land on the moon?," and so forth.

After the information (i.e., the answers to each question for each person) has been stored on the cards using this system of clipping or not clipping, the information can be retrieved with the use of a wire (bent out paper clip). Let's say you are interested in finding out who among the eight people is an architect. The answer to that question has been stored in hole two, so the cards would be stacked up (being careful to keep the clipped corner of each card in the same location so that hole two for each card falls on top of hole two for the other cards) and the wire would be placed through hole two. While loosely holding the cards in one hand, the wire should be pulled up. The wire will bring with it all cards for people who are not architects (remember, their hole two wasn't clipped); and the people who are architects will remain behind (because their hole two was clipped and the wire won't catch their cards).



In similar fashion one could ask a series of questions. For example, who among this group (if anyone) was an architect and research scientist? By successively placing the wire through the two holes associated with these two questions, any person with these two characteristics can be found. (In this case, none of the eight has these two characteristics.)


1. Are you a girl?
2. Do you usually walk to school?
3. Do you have a color t.v. in your room?
4. Etc.
5. --
6. --

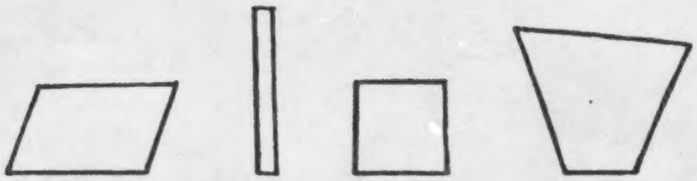
Having illustrated this sorting process, the resource person or teacher can lead students in an application of the sorting process to their classroom. Give each student a punched card with the corner clipped off. Each student should put their name on the top of the card. Students can suggest yes-no questions they would like answered about the class and these questions can be assigned to holes for the entire class, as is shown in the illustration. Students should copy the questions in the proper place on the cards; and they should clip or not clip the associated hole according to how they answer the questions themselves.

Cards can be sorted in various ways. For example, referring to the illustration, the wire could be placed through hole one in the stack of cards, and all the girls' cards would fall off the wire and the boys' cards would be caught by the wire.

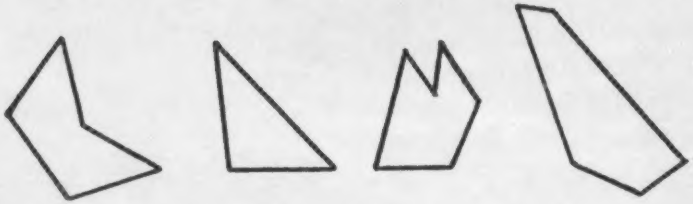
Following this activity, the resource person should be able to relate this card sort to the computer in one of two ways. First, one application of computers is keeping track of information. For example, a business may be interested in searching through its files to find former customers who would be good potential customers for a new product. The business could sort their customers into two groups, good and poor prospects, much as students sorted the cards. A second application of this activity is its illustration of how information is stored and read by a computer. Whether the information is stored on a card, tape, or disc, the information is stored at specific locations determined by the computer program (just as certain questions were assigned specific holes on the card). Also, the information is stored for the computer as a series of punched or not punched holes (or magnetised or unmagnetised spots) just as the information was stored on student cards as clipped or not clipped holes.

Worksheet 1

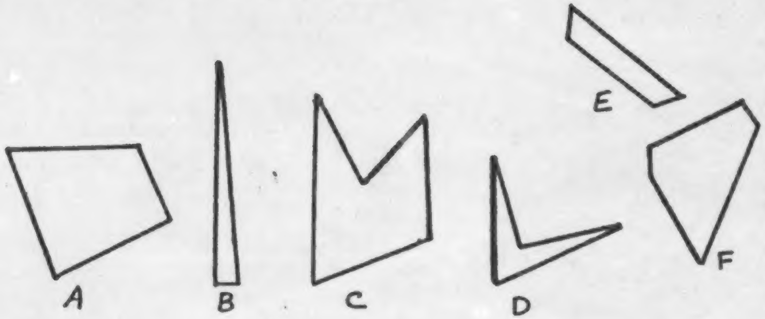
All of these are quads.



None of these are quads.

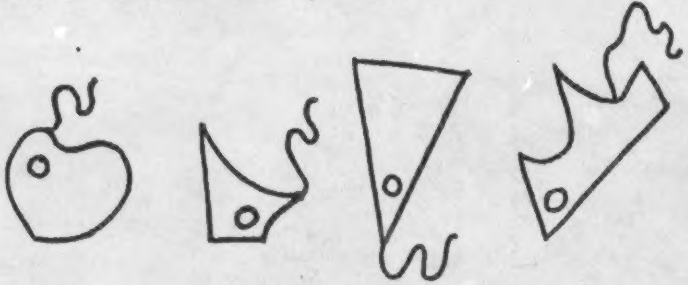


Which of these are quads?

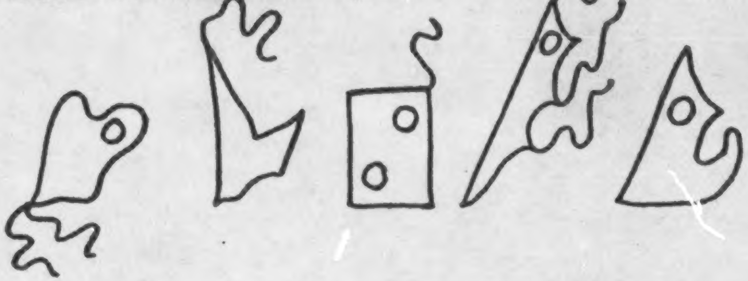


Worksheet 2

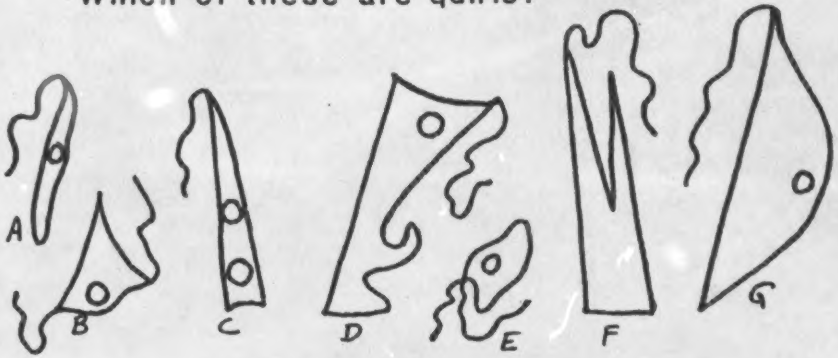
All of these are quirls.



None of these are quirls.

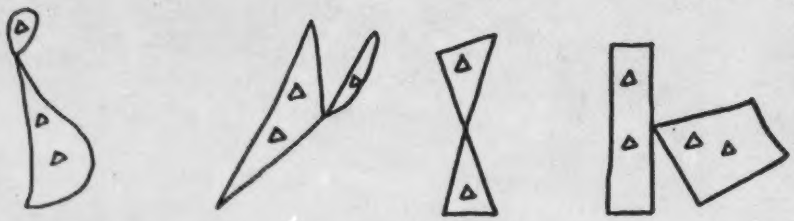


Which of these are quirls?

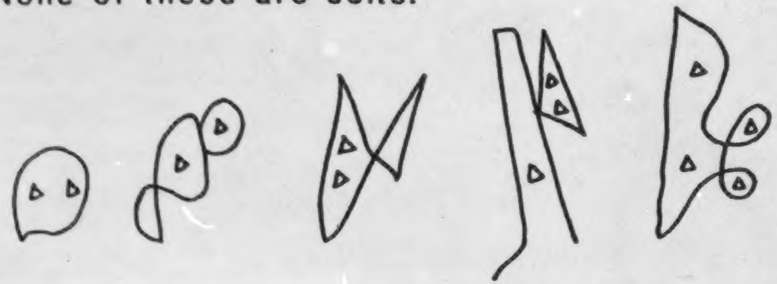


Worksheet 3

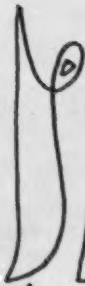
All of these are selts.



None of these are selts.



Which of these are selts?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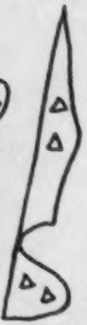
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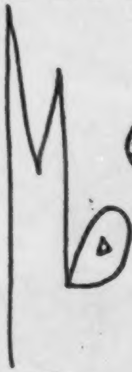
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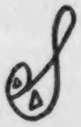
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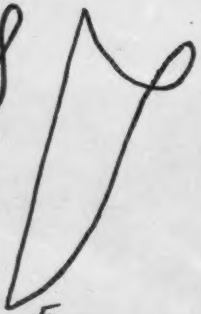
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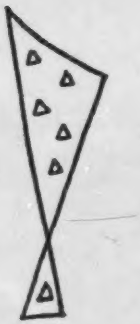
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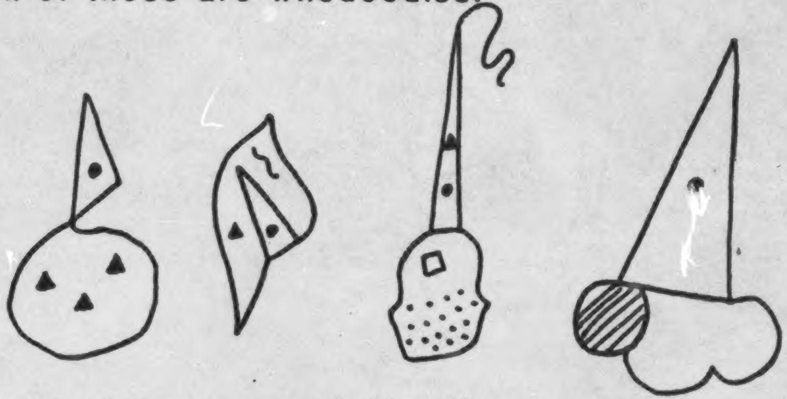
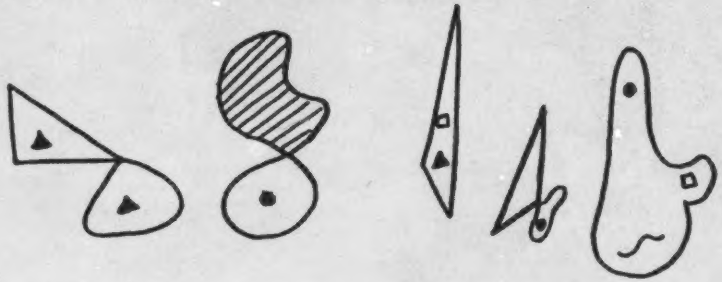
Worksheet 4

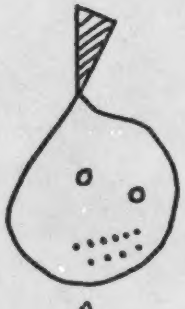
All of these are whodoodles.



None of these are whodoodles.



Which of these are whodoodles?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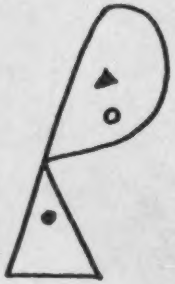
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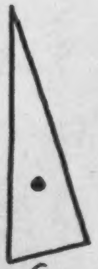
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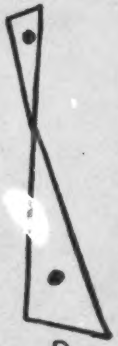
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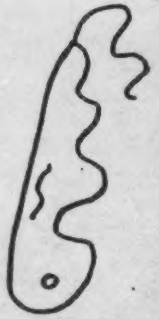
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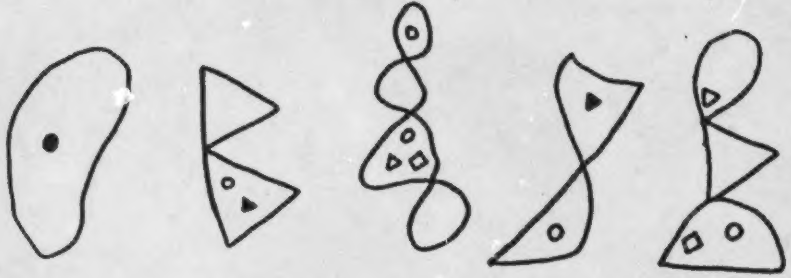
Worksheet 5

All of these are tellubs.



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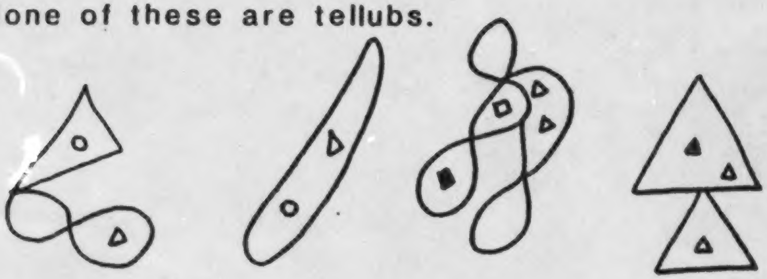
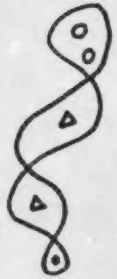


Which of these are tellubs?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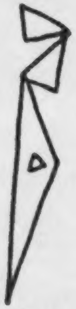
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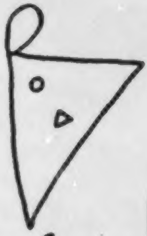
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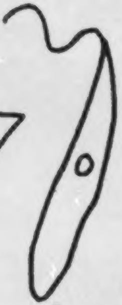
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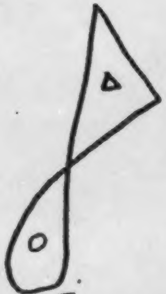
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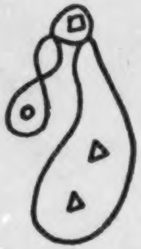
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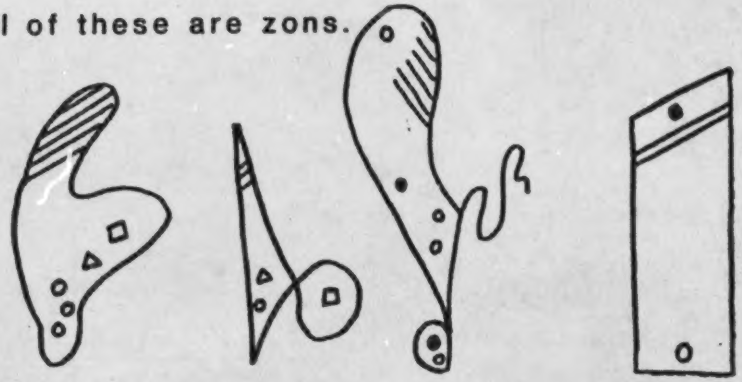
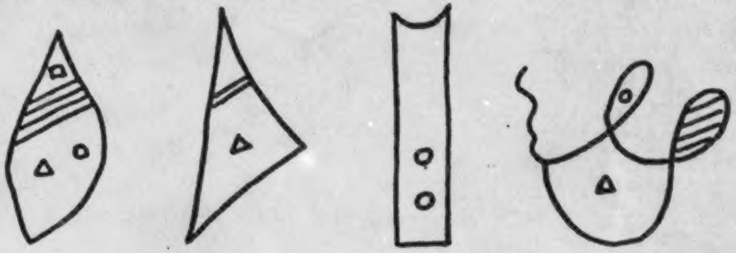
Worksheet 6

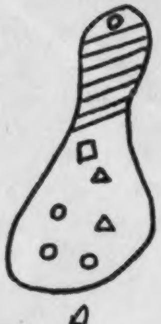
All of these are zons.



None of these are zons.



Which of these are zons?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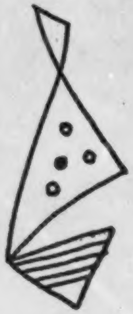
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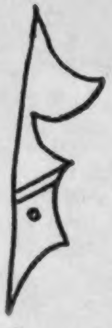
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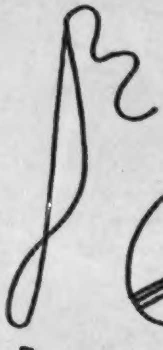
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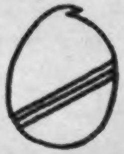
E

TOPICS

Computer

Logic

Program It

RESOURCE PEOPLE

Anyone
"Into"
Computers

Programmers

Systems Analyst

THIS MODULE

Activity I

"Flow Charts" teaches students how to outline solutions to problems as a series of commands and questions. The only required materials are copies of a worksheet for each student. The activity can be brief. The activity should be taught in a unit on computers, since computer programmers translate a flow chart into directions the computer can follow. The activity could also be taught in a unit on logic.

Activity II

"Writing Linear Programs" introduces students to computer programming, using BASIC, a simple, widely used computer language. Most home, business, and instructional microcomputers can be programmed in BASIC. Having a computer in the classroom is highly recommended for this activity. This activity can be brief; but if this activity is the students' introduction to microcomputers, probably little time will be left for talking about computer careers. Activity I should be done prior to this activity.

Activity III

"Writing Branching Programs" builds on and should follow Activity II. Having a computer in the classroom is highly recommended.

University of Kansas School of Education Department of Curriculum and Instruction

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RELATED MODULES

Program It is intended for computer professionals, including programmers and systems analysts. However, anyone who uses computers vocationally or avocationally, as long as they can use BASIC and microcomputers, could serve as a resource person. Since such a cross section of people could serve as resource people, all other modules may be used by specific resource people using this module.

Information Manipulation

Students learn to sort information using binary classification schemes, including a mechanical sort procedure analogous to computers' information processing procedure.

Chances Are

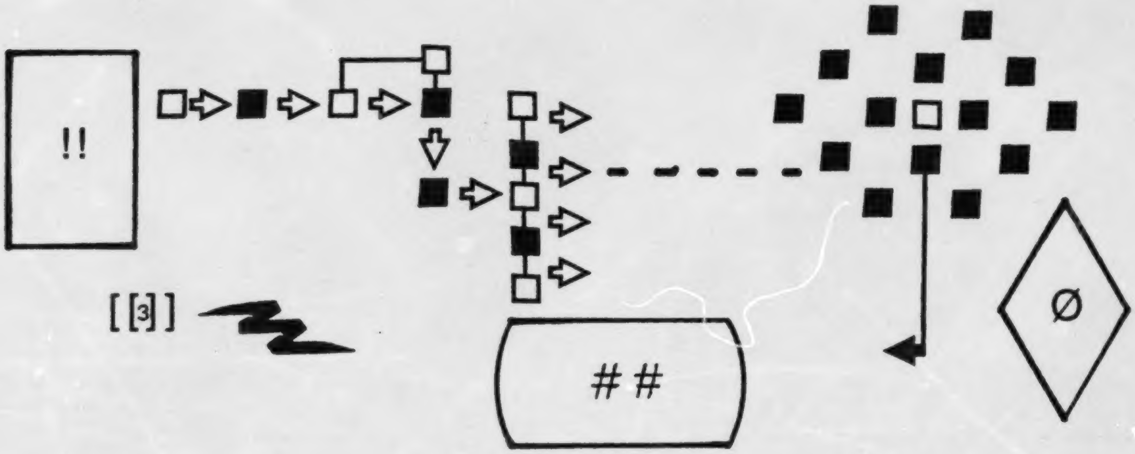
Students do various activities dealing with probability and sampling.

Figures Don't Lie

Sampling, graphing, and interpreting data are the focus of this module.

WHERE TO FIND RESOURCE PEOPLE

As computers become increasingly available, parents may be the best source of resource people. Many school systems have a computing staff and/or teachers who could serve as resource people. Local businesses, industries, governmental agencies, and hospitals may have a computing staff; or they may be able to refer you to computer service organizations which specialize in computer services. Computer stores or office supply stores may provide resource people themselves or provide references to individuals or computer clubs. Look in the yellow pages under computers. The local Chamber of Commerce may refer you to computer users or service organizations.



X

Women and Computers

In the mid-nineteenth century, Charles Babbage developed what is generally credited to be the first computer, even though his machine was never quite finished and that machine (with no electricity involved) is a far cry from contemporary computers. While Babbage pointed the way to computers, his colleague, Ada Byron Lovelace, is generally credited with being the first computer programmer. Her writings transformed Babbage's nearly incomprehensible ideas into a form more understandable to the public; and, more importantly, she provided the first clear instructions for how to program the computer. In essence, she said, "Here's what this machine can do and here's how you can make it work."

Following Babbage's only partial success with a mechanical computer, computer development languished for nearly a century. Then, during and immediately following World War II, the Mark I, II, and III computers, which were partially mechanical and partially electrical, were developed. Grace Hopper, a WAVE Lieutenant assigned to the Navy's Bureau of Ordinance Computation at Harvard and later a Harvard professor, developed the concept of automatic programming while working with these computers. That is, she developed the idea of the computer receiving instruction in a language somewhat similar to the everyday language of the person doing the programming and translating that language into a form with which the computer could work. Whereas prior to Grace Hopper's work, a programmer had to know how to communicate directly in "computer language" in order to instruct and understand the computer, now one could instruct the computer in a more natural sounding language. In short, she opened up computing to much more of the general public.

How could this be? What is so significant about what she did? To begin with, computers can work only in Base 2. Thus, whatever number is fed to a computer, the number first must be translated into Base 2; and when the computer provides numbers to the user, the reverse translation has to take place. The number 3 in Base 10 becomes 11 in Base 2, 4 becomes 100, 5 becomes 101, 6 becomes 110, and so forth. That number translation is not too difficult to master, but it alone can be a very tedious process. However, all communications with computers, not just numbers, must be translated into Base 2. Thus,

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translation is required for letters (A, B, C . . .), symbols (+, -, x, etc.), and commands, such as "move this number from here and store it there in the computer." To do a very simple process, such as "add a to b," requires lines of instruction to the computer in computer language. What Grace Hopper did was enable the programmer to simply instruct the computer to add a to b and force the computer to automatically translate that statement into a form with which the computer could work. She gave the computer a built-in translater.

Grace Hopper's particular work led to the language called COBOL which is widely used in business applications. However, a host of other languages such as FORTRAN, BASIC, PASCAL, and now ADA (in honor of Ada Lovelace) exist, just as a variety of human languages (Chinese, Italian, Swahili, and so forth) exist. Each language has its own best sphere of application, say in science, instruction, or artificial intelligence.

As you show students how to use BASIC in Activities II and III, relate to them the parts Ada Byron Lovelace and Grace Hopper played in the development of computer programming. If they ever become discouraged about programming, remind them that were it not for Grace Hopper, almost none of them would ever begin to use a computer.

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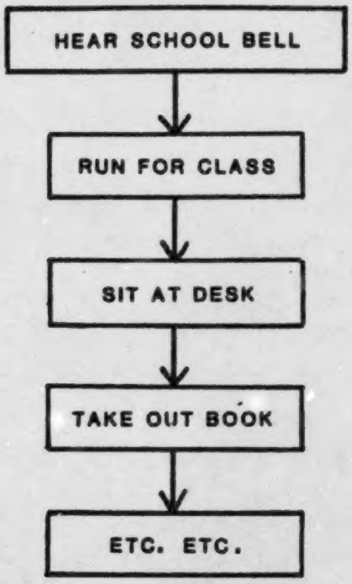
Activity I: Flow Charts

Materials:

- One copy of Flow Chart Worksheet per student.

Background Information:

Computers solve problems, but first the computer must be instructed about how to solve the problems. The instructions to the computer are contained in "programs." However, prior to writing a computer program, the programmer or systems analyst must figure out a "flow chart," which is a step-by-step procedure for solving the problem. Some flow charts are linear, that is, they move without variation from one step to the next. Here's a flow chart which shows a procedure frequently followed by students. The boxes indicate "commands," which in this case are directed to the student; but in a computer flow chart, the commands would be directed at the computer.



Since linear flow charts allow for no deviation in the order in which commands are given, they have limited use. To allow for variation in the order of commands, a branching flow chart is drawn. Embedded in a branching flow chart are yes-no questions (shown by ovals in the chart). If the answer to the question is yes, the flow chart branches in a different direction leading to different commands. Here's an example of a branching flow chart.

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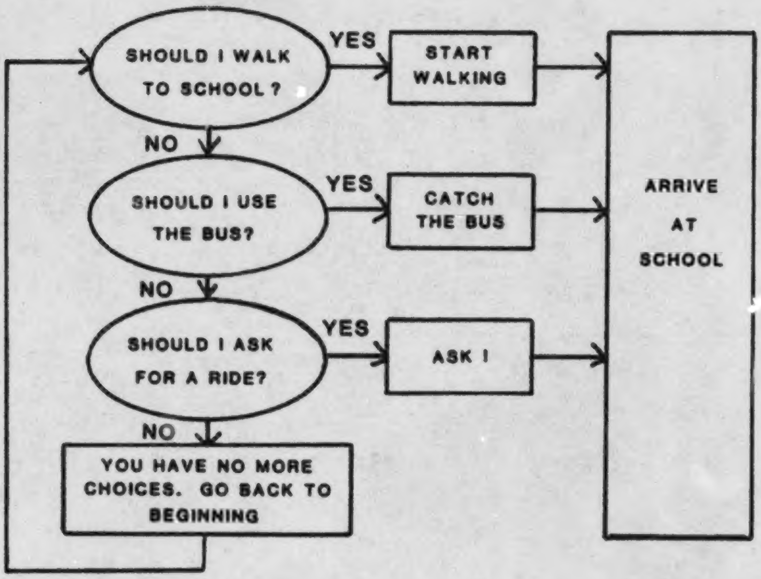

SHOULD I WALK TO SCHOOL?
YES
START WALKING
NO
SHOULD I USE THE BUS?
YES
CATCH THE BUS
NO
SHOULD I ASK FOR A RIDE?
YES
ASK!
NO
YOU HAVE NO MORE CHOICES. GO BACK TO BEGINNING
ARRIVE AT SCHOOL

Procedure:

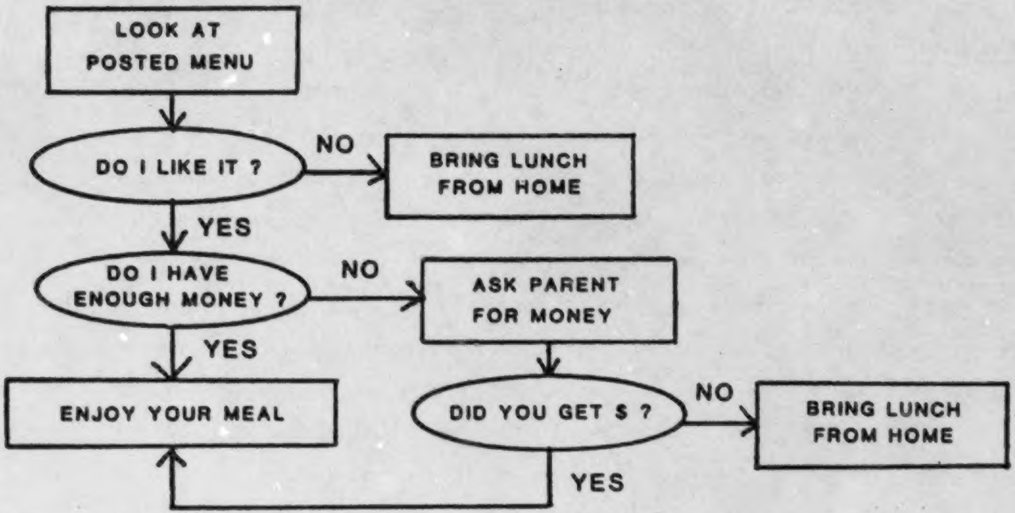
The resource person should briefly give students some information about flow charts and their purposes similar to the background information provided here. The sample flow charts for linear and branching programs can be drawn on the blackboard or reproduced on an overhead projector. Next, distribute the Flow Chart Worksheet to students and have them orally describe the flow chart to make certain they understand the directions summarized in the flow chart. Finally, have students write a flow chart for each of these problems which are also asked on the worksheet.

- Flow chart for deciding whether to eat school lunch or to bring lunch from home.
- Flow chart for taking a surprise quiz.

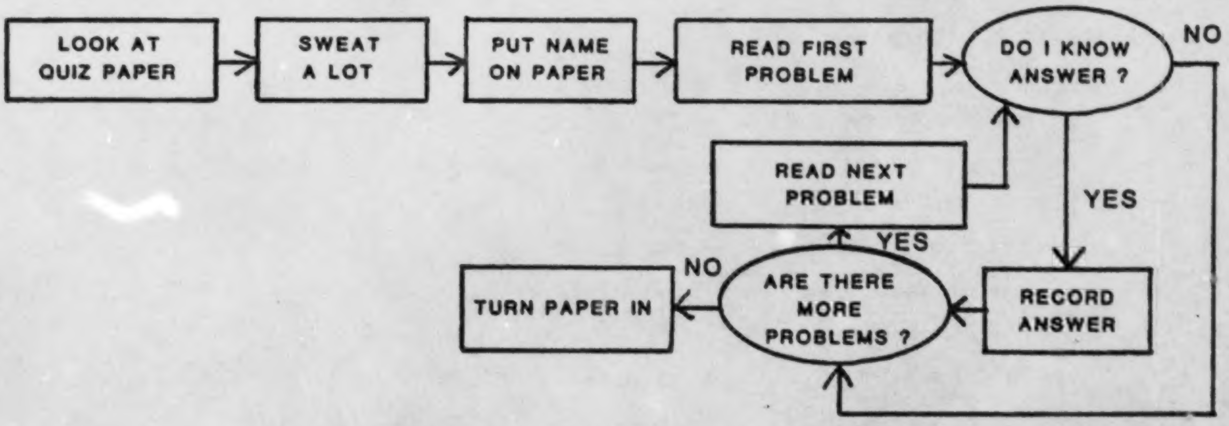
The resource person may choose to have students work as a group on one problem while putting their suggested flow chart on the blackboard. Here are possible flow charts for each of these problems. After completing these problems, the resource people should move on to relating the use of flow charts in their computing.

Possible Flow Charts:

LUNCH


LOOK AT POSTED MENU
DO I LIKE IT ?
NO
BRING LUNCH FROM HOME
YES
DO I HAVE ENOUGH MONEY ?
NO
ASK PARENT FOR MONEY
YES
ENJOY YOUR MEAL
DID YOU GET $?
NO
BRING LUNCH FROM HOME
YES

QUIZ


LOOK AT QUIZ PAPER
SWEAT A LOT
PUT NAME ON PAPER
READ FIRST PROBLEM
DO I KNOW ANSWER ?
NO
YES
READ NEXT PROBLEM
YES
RECORD ANSWER
NO
ARE THERE MORE PROBLEMS ?
TURN PAPER IN

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Activity II: Writing Linear Programs

Materials:

- Computer, if at all possible.

Background Information:

A computer must receive a specific set of instructions which indicate how it should arrive at a solution to a problem. The set of instructions or commands, which are called a program, correspond to the flow charts studied in Activity I. However, because the computer cannot understand the boxes, ovals, and arrows used to make a flow chart, a programmer must write instructions in a special language which the computer can understand. A language that is commonly used with hobby and instructional computers (the types which generally are available to schools and the public) is called BASIC (Beginner's All-Purpose Symbolic Intruction Code). Because BASIC is so universally used and relatively easy to learn, it is the language that will be introduced here.

Students should be told about Ada Lovelace and Grace Hopper (see "Women and Computers") who played very instrumental roles in the development of computer languages. The only thing computers can do is computations in Base 2. Thus, all numbers, letters, and symbols must be transposed from the language the programmer is using (e.g., BASIC) into the Base 2 numbers the computer can handle. Grace Hopper, preceded by Ada Lovelace, worked out procedures for making these transformations so that people could "communicate" with computers without going through the tedious task of translating their commands into Base 2.

Procedure:

This activity may follow Activity I or stand on its own. The teacher may want to do Activity I prior to the resource person's visit, so that students will have a feel for expressing a procedure for solving a problem as a series of commands. The resource person should begin Activity II by relating the information contained in "Background Information" and then begin to teach the BASIC language to students.

A BASIC program is written as a series of instructions. One instruction is written on one line of a program. Each program line begins with a step number indicated by an integer. When typing the program on a real computer, the RETURN key is struck at the end of each program line.

The computer executes the program lines in numerical order according to the step number (starting with the lowest number regardless of the order that the lines were typed into the computer. Therefore, programmers usually initially number program lines by tens, so that they can later add intermediate lines, if they find it necessary to do so. This will be illustrated later.) If as the program is being executed, the computer comes to a yes-no question, it will go to one set of commands, if the answer is yes, or to a second set of commands, if the answer is no. (This branching program is illustrated in Activity III.)

A frequently used command is PRINT. The word PRINT is followed by whatever you want the computer to print. If what follows PRINT is in quotation marks, the computer will print exactly what is in the marks (see Example 1 below). If you want the computer to print the results of some calculation, do not put what follows PRINT in quotation marks (see Example 2 below).

Example 1

You type in:

```
10 PRINT "6 + 7"
20 END
RUN
```

The computer prints out:

```
6 + 7
```

Example 2

You type in:

```
10 PRINT 6 + 7
20 END
RUN
```

The computer prints out:

```
13
```

Note that your last statement must be the command END preceded by a line number. This tells the computer that that program has come to an end. The next line should be RUN (with no line number, since it isn't part of the program) which tells the computer to execute the program. The computer may print the output on a TV screen, line printer, or whatever it has been directed to use. The resource person may need to tell students about special operating procedures of the computer being used for the demonstration (e.g., how to turn it on).

As is shown in Example 3, more than one calculation can be requested in a single program. (A flow chart is included next to Example 3 to show the relationship between the flow chart and the program. Since there are no yes-no questions, the program and flow chart are linear.)

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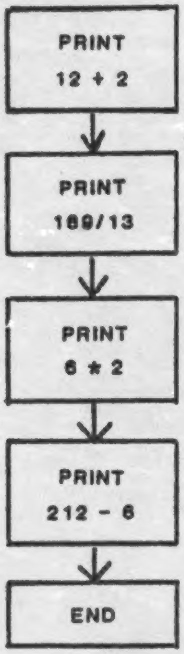
Example 3

Flow chart:



You type in:

```
10 PRINT 12 + 2
20 PRINT 169/13
30 PRINT 6 * 2
40 PRINT 212 - 6
50 END
RUN
```

The computer prints out:

```
    14
    13
    12
   206
```

Note that a slash (/) is used to indicate division and a star (*) indicates multiplication.

You do not have to limit yourself to the use of numbers. You can have the computer print out words (see Example 4).

Example 4

You type in:

```
10 PRINT "MY NAME IS -"  (Have student put in their name)
20 END
   RUN
```

The computer prints out:

```
MY NAME IS  (The statement will be completed by the student's name.)
```

The computer can also work with variables (see Example 5). Line 10 gives an initial value to the variable X. Line 20 takes the initial value of X and adds one to it. The X in line 30 does not have quotation marks, so the computer prints the current value of X.

Example 5

You type in:

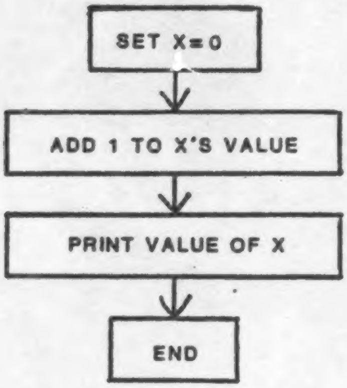
```
10 X = 0
20 X = X + 1
30 PRINT X
40 END
   RUN
```

The computer prints out:

```
          1
```

The computer can work with more than one variable (see Example 6).

Flow Chart

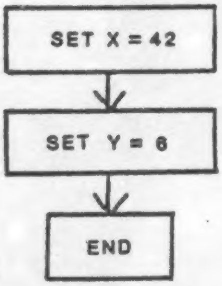


Example 6

You type in:

```
10 X = 42
20 Y = 6
30 END
RUN
```

Flow Chart



With this example the computer will print nothing, since it was not told to print. A PRINT can be added and given the line number 25, so it will be added between lines 20 and 30. The revised program is shown in example 7.

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Example 7

You typed in example 6:

```
10 X = 42
20 Y = 6
30 END
RUN
```

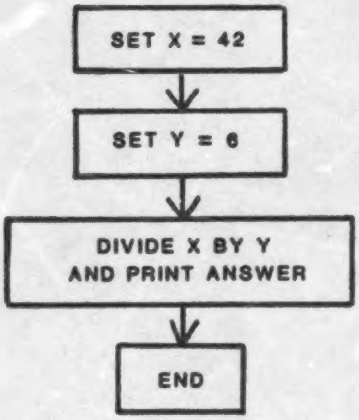
You noticed your mistake and added after RUN:

```
25 PRINT X/Y
RUN
```

The computer prints out:

```
7
```

Revised Flow Chart:


SET X = 42
SET Y = 6
DIVIDE X BY Y
AND PRINT ANSWER
END

At this point the resource person could go to Activity III which introduces branching programs or turn to relating this activity to their career.

Activity III: Writing Branching Programs

Materials:

- Computer, if at all possible.

Procedure:

Prior to doing this activity, students must have done Activity II or its equivalent. The resource person should introduce branching programs with the following information.

Linear programs tell the computer to perform a fixed sequence of commands. A branching program inserts yes-no questions into the program and sends the computer in one direction or another depending on the answer. Example 8 counts from 1 to 12.

Example 8

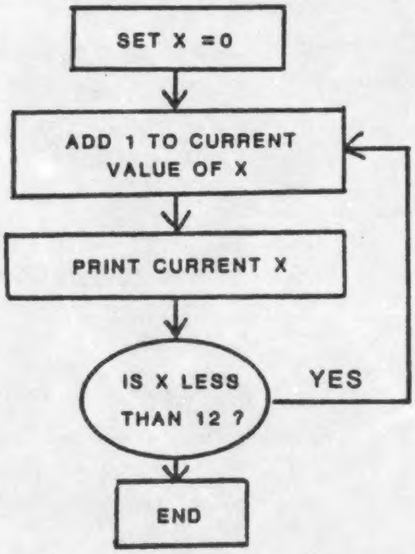
You type in:

```
10 X = 0
20 X = X + 1
30 PRINT X
40 IF X < 12 THEN 20
50 END
RUN
```

The computer prints out:

```
1
2
3
4
5
6
7
8
9
10
11
12
```

Flow Chart



In line 10 an initial value of 0 is given to X; and in line 20, 1 is added to the current value of X. In line 30 the current value of X is printed. Line 40 asks whether the current value of X is less than 12. If X is less than 12, then the computer goes back to line 20. The computer continues this cycle of lines 20 - 30 - 40 until the value of X is no longer less than 12. At that point the computer goes to line 50 and executes that statement.

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Extension Activity 1: Input

The computer programs illustrated so far have predetermined the values of variables. However, the computer can be programmed to accept values for variables while the program is being executed. That is done with the INPUT command. This command allows interaction between the computer and the operator while the program is being executed (see Example 9).

<u>Example 9</u>

You type in:

```
10 INPUT R
20 PRINT "R = ", R
30 END
RUN
```

The computer prints out:

```
?
```

When the computer comes to a step containing the INPUT command, it will print out a question mark, indicating that the operator must supply a number as an input. For example, when the question mark appears while running Example 9, suppose you type in 17 on the line containing the question mark printed by the computer. The computer will continue on to line 20, a print command, and print the material inside the quotation marks plus the value of R which you supplied. The computer printout then would look like this:

```
?   17          supplied by operator
R = 17          supplied by computer
```

Mathematical operations can be included in the program to allow calculations to be made on the input (see Example 10).

<u>Example 10</u>

You type in:

```
10 PRINT "ENTER THE 2 NUMBERS YOU WISH TO ADD"
20 INPUT X, Y
30 PRINT "X + Y = ", X + Y
40 GO TO 10
50 END
RUN
```

This program will continue to add whatever two numbers are input. It will never ask whether you wish to stop, and there is no way for the program to get to line 50. To allow you to stop when you want, you can modify the program by adding the following steps to Example 10.

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```
32 PRINT "DO YOU WISH TO DO ANOTHER PROBLEM?"
34 PRINT "TYPE 1 FOR YES OR 2 FOR NO"
36 INPUT T
38 IF T = 1 THEN 10
39 GO TO 50
RUN
```

Many other programs could be written to allow data to be put into a program to allow it to be flexible. The resource person could demonstrate additional applications of the INPUT command.

Career Information

Well over a million people are employed in various levels of computing, and many more people use computers in some aspect of their work. There are 660,000 computer operating personnel (including keypunch operators, data typists, and console operators), 247,000 computer programmers, and 182,000 systems analysts.

Systems analysts are the problem solvers of computing. They gather information about the problem needing solution and then outline a solution, much like the flow charts found in Activity I. They may work in manufacturing, banks, insurance, education, and so forth, or for a data processing service bureau which provides computing services to various customers. Systems analysts need a college education with major work in computing. In addition, they should have continual advanced training, because of the constant changes occurring in computing, plus training and/or experience in the area of problems being solved.

Once a problem solution has been developed by the systems analyst, the computer programmer translates the solution into a program which directs the computer to carry out the solution. A programmer may work only in a relatively simple language, such as BASIC which is used in Activities II and III, or in both the simple languages and the language which the computer can use without an intermediary translation step. The requirements for entry into computer programming are quite varied depending on the level of programming to be done. However, programmers increasingly have completed college with majors in computing plus experience and/or training in the area where they write programs.

The primary jobs of computer operating personnel are to enter programs and data into a computer and operate the computer to make it execute programs. These people usually must be high school graduates and have received training at a vocational or community college, in the military, or on the job.

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Related Activities:

Lewis, Bruce. Meet the Computer. New York: Dodd, Mead. 1977.

Sources of Additional Information:

Computing is an especially rapidly developing field. Therefore, magazines are a better source then books for keeping up on developments. Here are some of the current magazines.

Classroom Computer Notes, P.O. Box 266, Cambridge, Massachusetts 02138.

Creative Computing, P.O. Box 789-M, Morriston, New Jersey 07960.

Electronic Learning, Scholastic, Inc., 50 West 44th St., New York, New York 10036.

Mathematics Teacher and Arithmetic Teacher, National Council of Teachers of Mathematics, 1906 Association Drive, Reston, Virginia 22091. (Some articles or issues devoted to computing.)

On Computing, 70 Main Street, Peterborough, New Hampshire 03458.

Recreational Computing, P.O. Box E, Menlo Park, California 94025.

The Computing Teacher, Computing Center, Eastern Oregon State College, La Grande, Oregon 97850.

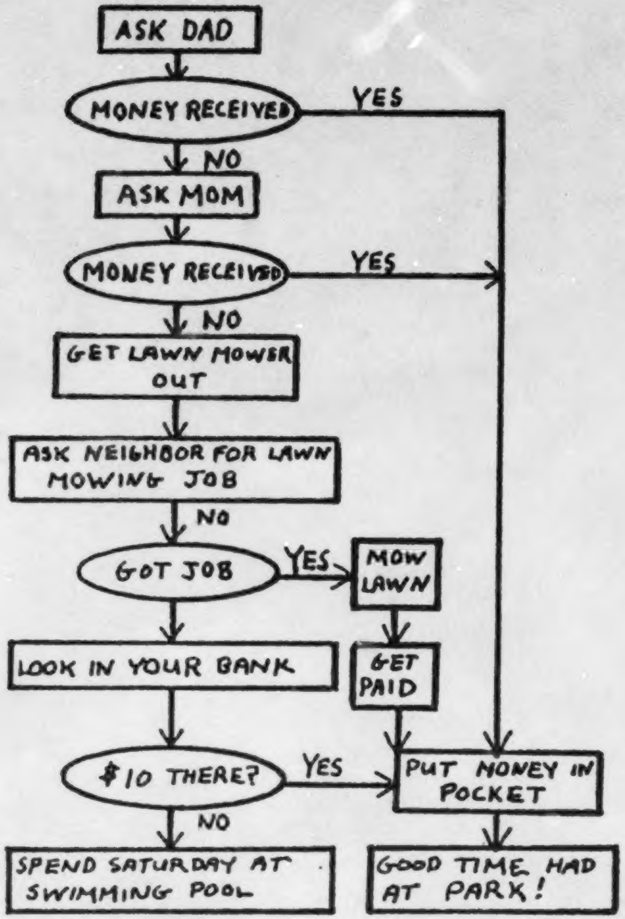
COMETS Profiles:

Sally Sedelow: Professor of Computer Science and of Linguistics. Can Shakespeare be analyzed by computer? Yes, by Sally Sedelow, who has wedded her three degrees in English Literature to computer analysis.

For More Career Information Write:

American Federation of Information Processing Societies, 1815 N. Lynn Street, Arlington, Virginia 22209.

Flow Chart Worksheet


ASK DAD
MONEY RECEIVED
YES
NO
ASK MOM
MONEY RECEIVED
YES
NO
GET LAWN MOWER OUT
ASK NEIGHBOR FOR LAWN MOWING JOB
NO
GOT JOB
YES
MOW LAWN
GET PAID
LOOK IN YOUR BANK
$10 THERE?
YES
PUT MONEY IN POCKET
NO
SPEND SATURDAY AT SWIMMING POOL
GOOD TIME HAD AT PARK!

Flowchart of Problem of Getting $10
To Go To Amusement Park on Saturday

PROBLEM 1

WRITE A FLOW CHART FOR: DECIDING WHETHER TO EAT SCHOOL LUNCH OR BRING LUNCH FROM HOME

PROBLEM 2

WRITE A FLOW CHART FOR: TAKING A SURPRIZE QUIZ

Bibliography of Biographies

ANTHROPOLOGY

MARGARET MEAD:

Mead, Margaret. Blackberry Winter. Morrow, 1972. (9+)
This autobiography of Mead (1901 - 1978) gives a very personal account of her life up to W.W. II. Mead writes very candidly of her professional and personal experiences and the effect they had on her as a woman. Recommended only for better readers.

Morse, Ann and Charles. Margaret Mead. Creative Education Society, 1974. (4-8)
Margaret Mead was an anthropologist and author who was one of the first professionals to actually live among primitive cultures and learn their languages and ways of life. She lectured and wrote on subjects such as tribes in New Guinea, American Indians, world population, peace, family relationships, racial tensions, and careers for women. The book provides an excellent explanation of anthropology in easy to understand terms and also gives a warm, descriptive, and full account of Mead's life. Illustrated with pictures.

ASTRONOMY

MARIA MITCHELL:

Baker, Rachel and Mitchell, Joanna B. America's First Woman Astronomer: Maria Mitchell. Messner, 1960. (5+)
Maria Mitchell (1818 - 1889) discovered a new comet which was named after her and for which the King of Denmark awarded her a gold medal. Until 1943 she was the only woman to have been elected to the American Academy of Arts and Sciences. This excellent book is written in a warm, informal, fictional manner. It does not use technical terms and would be of interest to casual readers as well as students of science.

VALENTINA TERESCHKOVA:

Sharpe, Mitchell R. "It is I, Sea Gull": Valentia Tereshkova, First Woman in Space. Crowell, 1975. (7+)
Valentina Tereshkova (1937 -), a Soviet Cosmonaut, was the first woman in space. In preparation for her historic flight she underwent arduous technical and physical training. She is now an aerospace engineer in the Soviet space program. This biography gives a good account of the life of Tereshkova. Since it is rather scientific and space-orientated, it might not appeal to the general reader.

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*Prepared by Carolyn Derusseau.

AVIATION

JACQUELINE AURIOL:

Auriol, Jacqueline. I Live to Fly. Dutton, 1970. (7+)
Jacqueline Auriol began flying as a hobby. A near fatal crash crushed her face; only the desire to become a professional pilot kept her from despair. She became a test pilot and has set many world's women's flying speed records. This first person narrative is a very moving, fascinating story of a courageous woman. Illustrated with photographs.

JACQUELINE COCHRAN:

Fisher, Marquita O. Jacqueline Cochran: First Lady of Flight. Garrard, 1973. (3-5)
Jacqueline Cochran (1912 -) had an impoverished childhood with almost no schooling; she worked in the cotton mills. As an adult she became interested in the cosmetic industry and in flying. She was twice named "Woman of the Year in Business" and was the first woman to break the sound barrier. This biography is warm, dramatic, and easy to read. Illustrated with pictures.

AMELIA EARHART:

Davis, Burke. Amelia Earhart. Putnam's, 1972. (6+)
Amelia Earhart (1898 - 1937) was the first woman to fly the Atlantic Ocean alone and the first person to fly solo between Hawaii and California. In 1937 she attempted a flight around the world, but her plane was lost in the Pacific and never found. This biography gives a substantial account of the adult motives, goals, and achievements of Earhart and is movingly and dramatically written.

CHEMISTRY/HOME ECONOMICS/ECOLOGY

ELLEN RICHARDS:

Douty, Esther. America's First Woman Chemist: Ellen Richards. Messner, 1961. (7+)
Ellen Swallow Richards (1842 - 1911) was the first woman to graduate with a degree in chemistry from the Massachusetts Institute of Technology. She was not charged tuition to go to school so that no woman would officially be recorded as a student. She was an expert in nutrition and helped develop the profession of home economics; and she also was a founder of the new science of ecology. This outstanding book gives a warm, personal account of Richard's life. It is not technical and would appeal to all readers.

ETHOLOGY

JANE GOODALL:

Coerr, Eleanor. Jane Goodall. Putnam's, 1976. (5+)
Even as a young child, Jane Goodall was fascinated with animals and knew she wanted to be a scientist. During several summers she set up a backyard museum to raise money for old horses. As an adult she studied chimpanzees in the jungles of Africa. She gave the chimps names such as Mr. McGregor, Flo, Olley and Fifi, and loved them as friends. This book is beautifully illustrated and interestingly written. It is especially appropriate for younger readers.

HELEN PERLEY:

Johnson, Eleanor. Mrs. Perley's People. Westminister, 1970. (5-9)
Helen Perley's scientific curiosity began at an early age. Her observations about animals are widely known and respected. Mrs. Perley has an animal farm where she raises and cares for many kinds of animals. She says the animals are her friends and have feelings, needs, wants, and desires just as humans do. She has a family of stuffed bears in her living room, and every animal on her farm has a name and its own cage. This is a fast moving, easy to read, narrative biography and is illustrated with photographs.

GEOLOGY

MARY ANNING:

Blair, Ruth Van Ness. Mary's Monster. Coward, 1975. (3-7)
Mary Anning (1799-1843) was not formally schooled in geology or science; but because of her serious and persistent pursuit of the study of fossils, she is recognized as an authority in this area. The book gives a fascinating, historically sound, though highly fictionalized account of Mary's search for fossils in the cliffs around her seaside home.

MEDICINE

ELIZABETH BLACKWELL:

Baker, Rachel. First Woman Doctor: Story of Elizabeth Blackwell, M.D. Messner, 1944. (6+)
Blackwell (1821 - 1910) was the first woman in America to receive a medical degree. During the Civil War, she and her younger sister, Dr. Emily Blackwell, helped select and train nurses. Blackwell was a pioneer in preventive medicine, sanitation, and public health. This excellent biography is well-written and should be fascinating to all readers.

DORTHEA DIX:

Baker, Rachel. Angel of Mercy: Story of Dorothea Lynde Dix. Messner, 1955. (6+)

Dorothea Dix (1802 - 1887) was a reformer and crusader for the mentally ill. She was responsible for the founding of 32 state mental hospitals. During the Civil War she was appointed superintendent of the U.S. Army nurses. This book is convincingly fictionalized and yet accurate and informative. It gives an outstanding, stirring, informal biography of Dix.

EMILY DUNNING BARRINGER:

Noble, Iris. First Woman Ambulance Surgeon. Messner, 1962. (6-10)

Emily Dunning Barringer (1876 - 1961) was the first American woman ambulance surgeon. She lived in a time when women physicians were few in number and often harrassed by male staff members. She was denied appointments to hospitals even though she graduated second in her class, but she refused to be discouraged. This biography is exciting and inspiring. It discusses Barringer's life from childhood through her internship at New York's Bellevue Hospital. It also explores the sex role sterotypes and prejudices that confronted her.

CONNIE GUION:

Champion, Nardi and Stanton, Rosamond. Look to this Day: The Lively Education of a Great Woman Doctor, Connie Guion, M.D. Little, 1965. (7+)

Connie Guion, M.D. was a remarkable woman whose career was marked by many "firsts" for women. She was a very warm person with many diverse interests; and she has been regarded as the modern dean of women doctors. The reader relives many of Guion's childhood experiences such as the birth of a younger sister, the dare to jump into a manure pile, and the run away mule, as well as experiencing the excitement of her very successful career. This biography is extremely well written and the many humorous anecdotes which Guion shared with the authors make it a most enjoyable reading experience.

ALICE HAMILTON:

Grant, Madeline. Alice Hamilton: Pioneer Doctor in Industrial Medicine. Abelard - Schuman, 1967. (7+)

Alice Hamilton (1869 - 1970) was the first woman appointed to the faculty of the Harvard Medical School and a crusader against many social injustices. She investigated lead factories and found that thousands of workers were being continually poisoned. This book gives an excellent narrative description of Hamilton and the society in which she lived. Illustrated with photographs.

ESTHER POHL LOVEJOY:

Burt, Olive W. *Physician to the World: Esther Pohl Lovejoy*. Messner, 1973. (7+)

Esther Lovejoy (1870 - 1967) was the first woman graduate of the University of Oregon Medical School. She made a wide variety of contributions through her medical profession such as Red Cross work, improving community medical and sanitary conditions, and developing orphanages, clinics and hospitals for disaster victims in Europe and Asia. This biography lacks distinctive literary style, but does give a dramatic, vivid account of Lovejoy.

MARIE ZAKREWSKA:

Victor, Agnes. *A Woman's Quest: The Life of Marie E. Zakrewska, M.D.* Appleton, 1974. (7+)

Marie Zakrewska (Zak-shef'ska) (1829 - 1902) was a Polish-German American who created several women's hospitals in New England. She was a great influence on women and a leader of women physicians. Part of this book is an autobiography which Zakrewska wrote to "encourage the average woman to determine and decide for herself to do whatever she can." She felt she had made great accomplishments through self-confidence, not through genius. This book is appropriate only for the best readers, but is a delightful reading experience.

NURSING

CLARA BARTON:

Nolan, Jeannette C. *The Story of Clara Barton of the Red Cross*. Messner, 1941. (6+)

Clara Barton (1821 - 1912) was best known as the founder of the American Red Cross. She started teaching school at the age of 18 and always was active as a humanitarian and leader of women's rights. During the Civil War she helped the injured, even in the line of fire. This biography is warm and interesting and gives a complete portrait of Barton and the society in which she lived.

MARY ANN BICKERDYKE:

deLeeuw Adele. *Civil War Nurse, Mary Ann Bickerdyke*. Messner, 1973. (6+)

Bickerdyke (1817 - 1901) was a nurse who distinguished herself during the Civil War by her sympathetic and excellent care of the wounded. After the war she was well known for her social welfare work, first in Kansas and later in New York and California. Bickerdyke was an assertive, energetic and determined woman. Temperance was one of Bickerdyke's strongest beliefs. Once in Lawrence, Kansas, she came across a man who was trying to get a signature for a saloon license. Instead of signing it, she grabbed and burned it. This is a fast moving, easy to read, narrative biography.

EDITH CAVELL:

Grey, Elizabeth. Friend Within the Gates: The Story of Edith Cavell. Houghton Mifflin, 1961. (5-9)

Edith Cavell (1865 - 1915) was an English born nurse and a spy during W.W.I. She was the head of a hospital in Belgium during the War and aided the escape of hundreds of Allied soldiers. Eventually her activities were detected by the Germans and she was sentenced to death by a firing squad. She was considered to be a martyr by her English contemporaries. This biography is very well written and gives an excellent account of both her early years as a nurse and her efforts as a war spy.

FRANCIS DAVIS:

Pitrone, Jean. Trailblazer: First Negro Nurse in the American Red Cross. Harcourt, 1969. (6+)

Francis Davis (1882 - 1964) was the first black nurse to be officially enrolled in the American Red Cross. Her mother died when she was five and she lived with various foster families. Finally one family befriended her and helped her gain an education. The book is informally written and gives a stirring and complete account of Davis' life. The author also presents a vivid picture of prejudice against blacks.

ALICE FITZGERALD:

Noble, Iris. Nurse Around the World: Alice Fitzgerald. Messner, 1964. (7+)

Alice Fitzgerald (1874 - 1962) was a nurse who received honors, decorations, and medals from many countries. She worked until the age of 74. This book is dramatic and inspiring and gives a good profile of the early days of the nursing profession as well as of Fitzgerald. It is very readable and interesting.

FLORENCE NIGHTINGALE:

Hume, Ruth. Florence Nightingale. Random House, 1960. (6-10)

Florence Nightingale (1820 - 1910) was a nurse, reformer, and organizer. She came from a wealthy, British family and dared to enter the nursing profession, which usually recruited from the lowest and most disreputable classes. During the Crimean War she organized and supervised nurses at the front. Her leadership reduced the death rate from 430 to 22 per 1,000. This biography gives a very fine, inspiring portrait of Nightingale and also thoughtfully examines the society in which she lived.

LINDA RICHARDS:

Baker, Rachel. America's First Trained Nurse: Linda Richards. Messner, 1962. (7+)

Linda Richards (1841 - 1930) was the first nurse to receive a diploma in the United States. She conferred with Florence Nightingale and studied her methods of training nurses. She opened the first nursing school in Japan and worked hard to raise the standard of nursing care in the U.S. This fine narrative biography is directed to all readers, not just those interested in the career of nursing. It gives a warm, dramatic portrait of Richards and also covers the history of nursing in the late nineteenth and twentieth centuries.

LILLIAN WALD:

Bloc, Irwin. Neighbor to the World: The Story of Lillian Wald. Crowell, 1969. (6-9)

Lillian Wald began her varied and distinguished career as a public health nurse by helping the immigrants who settled on New York's Lower East Side around the turn of the century. Eventually she established a world-famous settlement house, an ethnic theater, the first playground, and the first school health program. This book effectively portrays Wald as a compassionate, dedicated, and energetic woman and is written in a clear, interesting style.

OCCUPATIONAL THERAPY

ORA RUGGLES:

Carlova, John. The Healing Heart. Messner, 1961. (7+)

Ora Ruggles was a pioneer in the healing science of occupational therapy. She was born in 1894 in western Nebraska and was a tomboy; if a rifle or a bridle wasn't in her hands, then a baseball was. She preferred to dress-up a one-eyed barn cat in clothes instead of the beautiful dolls her mother would give her. During W.W.I Ruggles helped innumerable amputees learn new occupations and feel useful again. The book is written in a fascinating, narrative style and gives a very complete and interesting account of Ruggles' life. It is most appropriate for better readers.

OCEANOGRAPHY

RACHEL CARSON:

Sterling, Phillip. *Sea and Earth: The Life of Rachel Carson*. Crowell, 1970. (5+)
Rachel Carson (1907 - 1964) was a marine biologist, conservationist, and author. She felt that "man, making nature ugly for the best reasons or the worst, was making his own life ugly." Rachel was a warm, confident person who never needed other's approval. She always liked to write and had a story published in a magazine at age ten. During W.W.I she wrote pamphlets for the U.S. government to help increase the popularity of eating fish, since meat was scarce at home. In 1962 she wrote *Silent Spring*, which warned of the danger of insecticides. This biography is very well written and gives a full account of Carson's early childhood, family life, school, Pennsylvania homeland, and the development of her concerns about preserving nature. All readers would enjoy this book.

EUGENIE CLARK:

Clark, Eugenie. *Lady With A Spear*. Harper, 1953. (8+)
This book is written in a most interesting, fast-moving style. Clark tells of her childhood, youth, and adult career experiences. It is illustrated with pictures of Clark, her fish subjects, and the people with whom she worked. The book should be especially fascinating to those interested in marine biology.

McGovern, Ann. *Shark Lady, True Adventures of Eugenie Clark*. Four Winds Press, 1978. (5+)
Eugenie Clark's (1922 -) interest in fish started at age nine as the result of weekly visits to an aquarium in New York City. She loved sharks and wanted to study them and swim with them. She developed a major marine laboratory in Florida, studied the sleeping sharks in the caves of Mexico, and took a baby pet shark to the Prince of Japan. She advises people to "get involved in what interests you the most." This book is very informative, fast moving, humorous, and easy to read.

SCIENTIFIC RESEARCH

IRENE JOLIOT-CURIE:

McKowan, Robin. *She Lived For Science*. Messner, 1961. (7+)
Irene Joliot-Curie (1897 - 1956) was the daughter of Marie and Pierre Curie and, like them, was a scientist. She, along with her husband, was the winner of the 1935 Nobel Prize in chemistry. She successfully combined the roles of scientist, wife, and mother during her productive life. Although somewhat technical, this book moves along quickly and gives a complete account of Joliot-Curie's personal and professional life.

MARIE CURIE:

de Leeuw, Adele. Marie Curie: Woman of Genius. Garrard, 1970. (4-7) Marie Curie (1867 - 1934) was the scientist who discovered radium. Ironically, it was due to long exposure to the penetrating rays of radium that she died. She was the first woman to win the Nobel Prize in science and the first person to win it twice. She successfully combined a science career with marriage and motherhood. The book is well written and gives a good, clear portrait of Curie. Illustrated.

McKowan, Robin. Marie Curie. Putnam's, 1971. (4-8) This book gives an excellent account of Curie's life. It is well written and portrays Curie in a warm, inspiring manner. Illustrated.

LISE MEITNER:

Crawford, Deborah. Lise Meitner, Atomic Pioneer. Crown, 1969. (7+) Lise Meitner (1878 - 1968), a nuclear physicist, was shy and yet persistent and wanted to be like Marie Curie. She did not want to be "confined in the circle of kitchen, children and church." Her discoveries concerning uranium and thorium laid much of the groundwork for the atomic bomb. She felt scientists had a moral responsibility and was very unhappy about the uses made of her discovery. The book is somewhat technical but gives a very accurate, interesting account of Meitner's life as a female, Jewish scientist in the Nazi society during W.W.I.

FLORENCE SABIN:

Phelan, Mary Kay. Proving the Unknown: The Story of Dr. Florence Sabin. Crowell, 1969. (5-8) Florence Sabin (1871 - 1953) was a very modest, humble, and unusually brilliant person. She was a physician, scientist, and researcher who specialized in the investigation of the lymphatic system, blood vessels, and the origin of red blood cells. She made a three-dimensional model of the brain which is still used in medical schools. Although the book becomes technical in parts, it is written in a clear, interesting manner and is highly recommended for all readers.

MAUDE SLYE:

Slye, McCoy. The Cancer Lady. Thomas Nelson Inc., 1977. (7+) Dr. Maud Slye (1879 - 1954) was a scientist who dedicated 38 years of her life to cancer research. In her laboratory "only the mice are kings. All others are secondary," said Maud Slye. She found that the tendency of mice to be susceptible or resistant to cancer was hereditary. By selective breeding she eliminated many mouse diseases, thus enabling researchers to concentrate only on cancer. This book accurately and interestingly presents the story of cancer research and of the professional life of Slye.

COLLECTIVE

Bowman, Kathleen. New Women in Medicine, Children's Press, 1976. (5+)
Very brief, three to five page, biographies are presented for seven women in the medical field: Mary Calderone, Kathryn Nichol, Anna Elington, Mary Louis Robbins, Estelle Ramey, Margaret Hewitt, and Elizabeth Kubler-Ross. Interesting, easy to read, very personal biographies. Illustrated with photographs.

Emberlin, Diane. Contributions of Women: Science. Dillon, 1977. (7+)
This is an excellent book which explores the lives of six women scientists. It is very readable and gives accurate, vivid accounts of Annie Cannon, astronomer; Lillian Gilbreth, industrial engineer; Margaret Mead, anthropologist; Rachel Carson, marine biologist; Ruth Patrick, ecologist; and Eugenie Clark, icthyologist. The book is enhanced by many photographs.

Facklam, Margery. Wild Animals, Gentle Women. Harcourt, 1978. (7+)
This book is about eleven women who became animal watchers. Some are famous, others are little known. Some are trained scientists, others just happened into the study of animals. Some learned from animals in zoos, some in their own backyards, and others in oceans and jungles. All of these women are strong, patient, and capable and ask lots of questions about animals. The book is very well written and gives a warm, interesting, and often humorous account of the eleven women.

Fleming, Alice. Doctors in Petticoats. Lippincott, 1964. (5+)
This collective biography gives interesting, easy-to-read, narrative accounts of female doctors who lived in the late nineteenth and early twentieth centuries. Each short, approximately 20 page, biography gives a lively and fairly complete portrayal of the physician's life. Included in this book are biographies of Marie Zakrzewska, Emily Barringer, Clara Swain, Sara Jordan, and Connie Guion.

Gennett, Ann. Contributions of Women: Aviation. Dillon, 1975. (5-8)
This collective biography contains profiles of six famous female aviators: Amelia Earhart (1898-1937); Anne Morrow Lindbergh (1906-), navigator, pilot, and poet; Jacqueline Cochran (1912-), world record breaker of the jet age; Jerrie Mock (1925-), first woman to complete an around-the-world solo flight; Geraldine Cobb (1931-), first woman to pass the astronaut testing program; and Emily Howell (1939-), first female pilot for a U.S. scheduled airline. It is well organized, fascinating, and easy to read. Interesting anecdotes make for enjoyable reading. Illustrated with photographs.

Graham, Ada and Frank. Careers in Conservation. Scribner, 1980. (5+)
This collective biography is divided into two sections. The first gives a history of the American conservation movement; the second contains 13 profiles of conservationists who work in a wide variety of settings. Included in the book are profiles of four women: a game warden, an administrator for Central Park, a National Audubon Society representative, and a manager of a canyon in Arizona. The book is written in a fascinating manner and would be of interest to most readers.

Haber, Louis. Women Pioneers of Science. Harcourt, 1979. (6+)
This book contains biographies of twelve women in science. Special emphasis is given to current scientists and many scientific fields are represented. Profiles include, for example, those of Alice Hamilton, industrial medicine; Rachel Brown, biochemist; Dorothy Hodgkin, crystallographer; Jane Wright, physician and chemotherapist; and Rosalyn Yalow, nuclear physicist in medicine. The brief, narrative biographies present the highlights of each scientist's life.

Hirsch, Carol S. Guardians of Tomorrow: Pioneers in Ecology. Viking, 1971. (6+)
This book is extremely well written and thoughtfully organized. One chapter is on Rachel Carson's contributions to ecology. It is not a personal biography; the entire focus is on her work and writings. It does clearly reveal the extent of Carson's foresight, brilliance, and concern for the environment.

Hoyt, Mary Finch. American Women of the Space Age. Atheneum, 1966. (5-10)
This collective biography gives very brief accounts of the many women who are in the U.S. space program. A few of the women scientists in the book are Evelyn Anderson, an endocrinologist who works in space medicine; Alice Chatham, who helps develop space suits and helmets; Dorothy John, a mathematician; Julie Beaseley, an experimental psychologist; Merna Dawson, who analyzes fuels; and Mildred Mitchell, who works in the field of bionics. The book is illustrated and written in a non-technical, easy to read style.

Hume, Ruth. Great Women of Medicine. Random, 1964. (6-10)
The excellent, informal biographies found in this book are lively, readable, and accurate. They are further enhanced by photographs and old prints. Included are inspirational profiles of women who pioneered in the health fields: Florence Nightingale, nurse; Elizabeth Blackwell and Mary Putnam Jacobs, American physicians; Anderson and Jex-Blake, British physicians; and Curie, Nobel prize winning French scientist. There is also a chapter on more contemporary women.

Land, Barbara. The New Pioneers: Women in Antarctica. Dodd, Mead, 1981. (7+)
In Antarctica they've been snowed in at a remote camp, hauled equipment in subzero temperatures, looked for evidence of Gondwanaland, caught a falling star, and done much more. Land related the stories of over a dozen women who in the last decade have joined international teams of scientists to explore the last found continent. Students--both girls and boys--will be drawn into the exciting world of polar exploration while learning more about these adventurers as human individuals as well as career people.

McKowan, Robin. Heroic Nurses. Putnam, 1966. (5-9)
Nursing is as ancient as the human race. This is an unusually fine collection of profiles of nurses. It is well-documented, interesting to read, and would be valuable for all readers. Included in the book is a chapter on "nurses of time long past," plus profiles on 12 nurses, including Florence Nightingale, pioneer nurse; Mary Bickerdyke, Civil War nurse; Clara Barton, founder of the American Red Cross; Edith Cavell, nurse and spy; and Sister Elizabeth Kenny, polio nurse.

McLenighan, Valjean. Women and Science. Raintree, 1979. (6+)

Today there are more opportunities for American women in science than ever before, but the number of women scientists is still small. This book provides a brief look at six women and their careers in science. It is written in a concise, interesting, and easy-to-read manner. Among the six profiles are Annie Jump Cannon, an astronomer who identified and classified more stars than anyone else, and Alice Hamilton, a founder of industrial medicine. Others are Rachel Carson, Margaret Mead, Florence Sabin, and Chien Shung.

Noble, Iris. Contemporary Women Scientists of America. Messner, 1979. (7+)

This book focuses on twentieth century American women who have made great contributions in science. Included are Margaret Mead, anthropologist; Joanne Simpon, meteorologist; Dixie Lee Ray, marine biologist; Isabella Karle, crystallographer, and chapters on seven other twentieth century scientists. The profiles are well written, factually accurate, and complete. The style is easy to read and should be valuable for most readers.

Poole, Lynn and Gray. Scientists Who Work Outdoors. Dodd, 1963. (7+)

This very fine biography focuses on the professional careers of marine biologist, Dixie Lee Ray, and anthropologists, Margaret Mead and Betty Jane Meggers. It discusses their education and early training as well as some of their later accomplishments. It is highly readable and would be of particular value to those wishing to know more about the professions of the subjects.

Wright, Helen and Rapport, Samuel. Great Adventures in Nursing. Harper, 1960. (7+)

This fast moving and fascinating book explores many nursing adventures and is designed to interest readers who want to know more about nursing as well as those who just enjoy reading an exciting story. It is divided into three sections; Hospital Adventures, From the Jungle to the Slum, and Adventures in War.

Yost, Edna. Women of Modern Science. Dodd, 1959. (7+)

This is a collective biography of twelve women scientists. The author and publisher were concerned that in America so few women are encouraged to enter science-related careers. Therefore, this book was written with young women in mind and was intended to inspire the pursuit of scientific interests. Scientists included in this book are Helen Hogg, astronomer; Elizabeth Russell, zoologist-geneticist; Chien Schung Wu, nuclear physicist; Edith Quimby, physicist; Gladys Emerson, biochemist; and Dorothea Rudnick, embryologist. Good, brief sketches of interesting women scientists. Most appropriate for better readers.

GENERAL

Fenten, D.X. Ms - M.D. Westminister Press, 1974. (7-12)

This book is designed especially for young women interested in a medical career. It gives information about scholastic preparation, medical specialities, and challenges facing women in medicine. The book is both informative and entertaining and covers the subject of female physicians very thoroughly.

Goldreich, Glori and Esther. What Can She Be? An Architect (1974), What Can She Be? A Computer Scientist (1979), What Can She Be? A Film Producer (1972), What Can She Be? A Geologist (1976), and What Can She Be? A Veterinarian (1972), all from Lothrop. (1-5)

All these books are easy to read and filled with interesting pictures. Each follows the life of one woman and gives a good account of her professional and personal daily activities.

Hewett, Joan. Watching Them Grow. Inside a Zoo Nursery. Little, 1979. (5-10)

This book gives a behind the scenes view of the baby animal nursery at the San Diego Zoo. It covers approximately four months in the lives of Kalind, a pygmy chimpanzee; Loch and Lisa, orangutan twins; Dracula, a spider monkey; and A-Seven, an aardvark. The book is filled with photographs of the nursery attendants and animals as they go through the daily activities in the nursery. The book is very informative and fascinating. Its content and style make it appealing to almost any reader.

Jochnowetz, Carol. Careers in Medicine for the New Woman. Watts, 1978. (5-9)

This book discusses the qualities needed to become a physician and includes chapters on medical training, medical schools, specialities within medicine, and combining a practice with a family. It also has brief interviews with women in medicine throughout the book. The book is very factual and informative and yet is written in an interesting and easy to read style. Contains many photographs.